ARMY
SBIR 06.2 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: http://www.aro.army.mil/arowash/rt/.

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 (1 May – 13 Jun 2006), contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period (14 Jun – 14 Jul 2006), 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)
6000 6th Street, Suite 100
Fort Belvoir, VA 22060-5608
(703) 806-0963
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)** and **Azimuth, Inc**. who will provide Advisory and Assistance Services to the Army, providing technical analysis in the evaluation of proposals submitted against Army topic numbers: **A06-162** and **A06-164**.

Individuals from **Science Applications International Corporation (SAIC)** and **Azimuth, Inc**. will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. This firm is expressly prohibited from competing for SBIR awards and from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the source selection process, the aforementioned firm 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 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.

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, the following information should be provided: individuals full name (including alias or other spellings of name), date of birth, place of birth, nationality, registration number or visa information, port of entry, type of position and brief description of work to be performed, address where work will be performed, and copy of visa card or permanent resident card.

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

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 proposal must be included within the 25-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 "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 counts toward the 25-page Phase I proposal limitation.

Phase I Key Dates

06.2 Solicitation Pre-release	1 May – 13 Jun 2006
06.2 Solicitation Open	14 Jun – 14 Jul 2006
Phase I Evaluations	July - September 2006
Phase I Selections	September 2006
Phase I Awards	November 2006*

**Subject to the Congressional Budget process*

PHASE II PROPOSAL SUBMISSION

Note! Phase II Proposal Submission is by Army Invitation.

Small businesses are invited by the Army to submit a Phase II proposal from Phase I projects that have demonstrated the potential for commercialization of useful products and services utilizing the criteria in Section 4.3. The invitation will be issued in writing by the Army organization responsible for the Phase I effort. Invited small businesses are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology in their Phase II proposal.

Phase II proposals are only accepted from the small businesses that are invited in writing by the Army organization responsible for the Phase I effort.

Army Phase II cost proposals must contain a budget for the entire 24 month Phase II period normally 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. At the Contracting Officer's discretion, Phase II projects may 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, but must submit an application and Phase II proposal by the Army Phase II submission date. Applications are only accepted from the most recent Army topic Solicitation.

Phase II Plus Program. The Army established the Phase II Plus initiative to facilitate the rapid transition of SBIR technologies, products, and services into acquisition programs. Under Phase II Plus, the Army provides matching SBIR funds up to $500,000 to expand an existing Phase II that attracts non-SBIR investment funds. Phase II Plus allows for an existing Phase II Army SBIR effort to be extended for up to one year to perform additional research and development. Visit the Army SBIR web site for additional information and application instructions at http://www.aro.army.mil/arowash/rt/.

Phase II Key Dates

Phase II Invitation	March 2007+
Phase II Proposal Receipt	2007+
Phase II Evaluations	May – June 2007
Phase II Selections	June 2007
Phase II Awards	October 2007*

**Subject to the Congressional Budget process*
+ Subject to change; consult ARO-W web site listed above

CONTRACTOR MANPOWER REPORTING (CMR)

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

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

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

- The Office of the Assistant Secretary of the Army (Manpower & Reserve Affairs) operates and maintains the secure CMR System. The CMR website is located here: https://contractormanpower.army.pentagon.mil/.

- The CMR requirement consists of the following 13 items, which are located within the contract document, the contractor's existing cost accounting system (i.e. estimated direct labor hours, estimated direct labor dollars), or obtained from the contracting officer representative:

    (1) Contracting Office, Contracting Officer, Contracting Officer's Technical Representative;
    (2) Contract number, including task and delivery order number;
    (3) Beginning and ending dates covered by reporting period;
    (4) Contractor name, address, phone number, e-mail address, identity of contractor employee entering data;
    (5) Estimated direct labor hours (including sub-contractors);

(6) Estimated direct labor dollars paid this reporting period (including sub-contractors);
(7) Total payments (including sub-contractors);
(8) Predominant Federal Service Code (FSC) reflecting services provided by contractor (and separate predominant FSC for each sub-contractor if different);
(9) Estimated data collection cost;
(10) Organizational title associated with the Unit Identification Code (UIC) for the Army Requiring Activity (The Army Requiring Activity is responsible for providing the contractor with its UIC for the purposes of reporting this information);
(11) Locations where contractor and sub-contractors perform the work (specified by zip code in the United States and nearest city, country, when in an overseas location, using standardized nomenclature provided on website);
(12) Presence of deployment or contingency contract language; and
(13) Number of contractor and sub-contractor employees deployed in theater this reporting period (by country).

- The reporting period will be the period of performance not to exceed 12 months ending September 30 of each government fiscal year and must be reported by 31 October of each calendar year.

- According to the required CMR contract language, the contractor may use a direct XML data transfer to the Contractor Manpower Reporting System database server or fill in the fields on the Government website. The CMR website also has a no-cost CMR XML Converter Tool.

- The CMR FAQ explains that a fair and reasonable price for CMR should not exceed 20 hours per contractor. Please note that this charge is PER CONTRACTOR not PER CONTRACT, for an optional one time set up of the XML schema to upload the data to the server from the contractor's payroll systems automatically. This is not a required technical approach for compliance with this requirement, nor is it likely the most economical for small businesses. If this is the chosen approach, the CMR FAQ goes on to explain that this is a ONE TIME CHARGE, and there should be no direct charge for recurring reporting. This would exclude charging for any future Government contract or to charge against the current SBIR contract if the one time set up of XML was previously funded in a prior Government contract.

- Given the small size of our SBIR contracts and companies, it is our opinion that the modification of contractor payroll systems for automatic XML data transfer is not in the best interest of the Government. CMR is an annual reporting requirement that can be achieved through multiple means to include manual entry, MS Excel spreadsheet development, or use of the free Government XML converter tool. The annual reporting should take less than a few hours annually by an administrative level employee. Depending on labor rates, we would expect the total annual cost for SBIR companies to not exceed $500 annually, or to be included in overhead rates.

PHASE I SUMMARY REPORTS

All Phase I award winners must submit a Phase I Final Summary Report at the end of their Phase I project. The Phase I 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 Portal. A summary report should not exceed 700 words, and should 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 Phase I summary report shall be submitted in accordance with the format and instructions posted on the Army SBIR Small Business Portal website at http://www.aro.army.mil/arowash/rt/. This requirement for a final report will also apply to any subsequent Phase II contract.

ARMY SUBMISSION OF FINAL REPORTS

All final 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 06.2 Topic Index

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

A06-001	Autonomous Navigation and Obstacle Avoidance for Small Unmanned Aerial Vehicles without Global Positioning System
A06-002	Rotorcraft Automated Load and CG Balance Measurement System
A06-003	Terrain/Obstacle Sensors for Rotorcraft Synthetic Vision Displays
A06-004	Unmanned Aerial Vehicles Launch and Recovery On the Move (UAVLR-OTM)
A06-005	Design and Development of an Inter-Turbine Burner for Turboshaft Engines
A06-006	Low Reynolds Number, High-Lift Airfoil Development for Vertical Takeoff and Landing Uninhabited Aerial Vehicles (VTOL UAVs)
A06-007	Delegation of Authority to Intelligent Unmanned Aerial Vehicle (UAV) Team Members
A06-008	Advanced Inlet Protection System in Severe Sand Environments
A06-009	Rapid Computational Fluid Dynamics (CFD) Methodology for Rotorcraft Maneuver Analysis
A06-010	Assembly of Ceramics/Ceramic Matrix Composite (CMC) Components
A06-011	Wireless Pressure Transducer
A06-012	Wake-Capturing Methods for General and Heavy-Lift Rotorcraft Flow Analysis

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

A06-013	Enhanced Strength & Durability in Zinc Sulfide
A06-014	Low Elevation Nulling of Global Positioning System (GPS) Jammers for Ground-Based Platforms
A06-015	Low Cost Finishing of Optical Ceramics
A06-016	Missile Flight Weather Encounter Software for System Requirements Development
A06-017	Super-Nanocomposite Components for Advanced Interceptors
A06-018	Computational Fluid Dynamics Modeling for Electrically Conducting Flows
A06-019	Dissolvable Jet Vanes for Rocket Propelled Missiles
A06-020	Transient, Rocket Exhaust Plume Modeling for Static Test Analyses
A06-021	Modeling and Simulation of Missile and Munition Power Sources
A06-022	Software-Based Anti-Tamper Technique Research and Development
A06-023	Alternate Green Body Dome Fabrication Techniques
A06-024	Green Body Machining of Domes
A06-025	Novel Characterization and Measurement of Radar Ground Clutter for Modeling and Simulation
A06-026	Metrology for Aspheric Domes
A06-027	Multi-functional Polymers for Composite Structures
A06-028	Manufacturing and Producibility of Gelled Propellants
A06-029	Hybrid Composite for Beryllium Replacement in Missile Defense Interceptors
A06-030	Anti-Tamper Active and Passive Sensors for Use Inside an Integrated Circuit
A06-031	Affordable Electro-Magnetic Interference (EMI) Grid Application
A06-032	Software Sentinel Anti-tamper Technique
A06-033	Improvements in Yttria Strength for Durable Windows
A06-034	Hardware-Based Anti-Tamper Techniques
A06-035	Assessment Tool for Determining Product Assurance Readiness Levels
A06-036	Multifunctional Nanodevice Skins for Cognitive Missiles

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

A06-037	Near Real Time Structure Mapping for Urban Combat
A06-038	Low Cost, Improved Thermal Batteries
A06-039	Versatile Sensor Network/Data Fusion Optimization System
A06-040	Innovative Thermal/Chemical Resistant Coating Material
A06-041	Integration of a Laser Range Finder into a Stabilized Binocular
A06-042	High Speed Innovative Electronic Image Stabilization
A06-043	Automated Target Hand-Off for Future Force Operations

A06-044	Innovative Computer-Aided Manufacturing
A06-045	Automatic Target Detection and Recognition Algorithms for Hyperspectral Sensors
A06-046	Novel Plasma Stabilization and Control of Titanium Welding Processes
A06-047	Innovative Harware-Based Chip Control Technologies
A06-048	Innovative Polarized RF Reference Sources
A06-049	Novel Miniature Inertial Igniters for Thermal Batteries
A06-050	Novel Actuators for Active Aerodynamic Control of Gun Fired Munitions
A06-051	Infrared Hyperspectral Linear Array Sensor
A06-052	Collaborative Engagement with Unmanned Systems
A06-053	GPS Denied Guided Gun Fired Smart Munitions
A06-054	Advanced Processing Techniques for Novel High Strength Magnesium Alloys
A06-055	High Temperature Sensor for Consolidation of Refractory Metals and Alloys
A06-056	Innovative Predictive Model for Determining Bore Erosion
A06-057	High Efficiency Quantum Dot Based Photo Voltaics
A06-058	Synthesis of Nano Composite Super Thermites with Tunable Energy Release

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

A06-059	Virtual Demonstrations for Infantry Training
A06-060	Team Composition Optimization Tools

Army Research Laboratory (ARL) **Vincent Marinelli** **(301) 394-4808**

A06-061	Flexible Electronics for Rugged, Low Power Army Systems
A06-062	Compact, Lightweight Ultrafast Laser Source for Field Sensors
A06-063	Fluctuation-Enhanced Chemical & Biological Sensor Systems
A06-064	Dynamic Ad-Hoc Network Communications Visualization and Control
A06-065	High Sensitivity Rugged Array Detectors for Field Deployed Instruments
A06-066	Compact Direct Methanol Fuel Cell Power System Using Pulsed Electrical Control
A06-067	Stereoscopic 3D Viewing of Single-sensor Video from Moving Surveillance Platforms
A06-068	Effects of Damage to Composite Materials
A06-069	Structural Damage Effects to Army Vehicles
A06-070	LIBS-Based Deminer's Probe for Buried Landmine Detection
A06-071	Awareness and Recognition of Behavioral Threat within Complex Environments: Detection of Intent from Biomotion Signatures
A06-072	Mobile Toxic Hazard Transport and Diffusion Analysis and Prediction Tool
A06-073	Lightweight Structural Energetic Composites for FCS Munitions
A06-074	Design and Development of a Micro Solid State Cooling Device for Harsh Battlefield Environments
A06-075	Simulation Tools for Strain Engineering, Manufacturing and Design of Novel Optical and Electronic Superlattice Materials and Surfaces
A06-076	Novel, Low Cost Superhydrophilic Anti-Fog Coatings to Maintain Transparency
A06-077	High Power Density Gears Using a Systems Engineering Approach for Selection, Test, and Evaluations of Emerging Materials, Surface Engineering, and Tribology Solutions
A06-078	New and Improved Nonaqueous Electrolyte Components - Salts and Solvents
A06-079	Identification of Cultural Demographics to Predict Community Responses to Military Operations
A06-080	Coatings for Field Repair of Transparent Materials
A06-081	Efficient and Novel Algorithms for RADAR Systems with Phased Array Antennas
A06-082	Multifunctional Erosion Resistant Coatings for Turbine Engine Components
A06-083	A Process to Produce High-Purity Encapsulated Particulates in Large Quantities
A06-084	Reliable Biometrics Data Quality Measure for Multi-modality Biometrics Fusion

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

A06-085	Real-Time Tracking of Multiple Entities Within a Complex Joint Urban Environment
A06-086	Multiplex Data Bus Controller/Translator

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

A06-087	Improved Web-Based Mapping

A06-088	Automated World-View Construction for a Multi-Modal Mobile Mounted Sensor Suite
A06-089	Helmet Antenna System
A06-090	Detection and Neutralization of Improvised Explosive Devices
A06-091	Lithium-Air Hybrid for Soldier, Sensor and Unmanned Aerial Vehicle (UAV) Power
A06-092	Low-Power/Low-Cost Global Positioning System (GPS) Receiver Card
A06-093	Efficient JP-8 Burners for Soldier Portable Stirling Power Systems
A06-094	Models to Address Diplomatic, Information, Military, Economic (DIME) Factors for the Propagation/Evolution of Ideas Through Defined Populations
A06-095	Real-Time Three-Dimensional (3D) Visualization for On-The-Move (OTM) Applications
A06-096	Regenerable Sulfur Removal and Processing of Diesel and JP-8 Logistics Fuels for Fuel Cell Auxiliary Power Units
A06-097	Micro-Power Generation Suite For Future Combat Systems (FCS) and Global War on Terror (GWOT): Watts To Kilowatts
A06-098	Innovative Integration Layer for Signal Analysis Support
A06-099	Low Jitter Clock Source for Radio Frequency Data Converters
A06-100	Reactive, Multi-Layer Simulation Technologies
A06-101	Image and Character Restoration Module for Arabic Text Documents
A06-102	On-the-Move Geolocation of Very Weak RF Signals in Urban Environments
A06-103	Advanced Fast Tuning Low Phase Noise, Low Power Consumption, Wideband Tuner for Electronics Warfare (EW) Applications
A06-104	Portable Terahertz Imaging System
A06-105	Propagation Modeling of Near Ground Radio Signals
A06-106	Advanced People and Wildlife Discrimination Algorithms for Radar
A06-107	Improved Efficiency of 2.09 Micron Pump Laser
A06-108	Prioritization for Improved Effectiveness of Co-Located Wide and Narrow Field-of-View Sensors
A06-109	Wideband, Interference Rejecting Antenna Subsystem
A06-110	Compact, Wideband, Single or Dual Antenna Geolocation
A06-111	Compact Fast Tunning Direct Digital Synthesizer (DDS) Signal Generator for Electronics Warfare (EW) Jammer Systems
A06-112	Advanced Algorithms for Distributed Fusion (A2DF)
A06-113	Geometric Pairing (GP) of battlefield entities thru the Combat Net Radio System (CNRS)
A06-114	Uncooled Long-Wave Infrared (LWIR) Hyperspectral Sensor
A06-115	Micro Solid State Low Light Level Camera
A06-116	Improved Far-Target Location Accuracy for Man-Portable Systems Through Application of Micro-Electro-Mechanical Systems (MEMS)-Gyro / Magnetometer Hybrid Sensor & 3-D Compensation Algorithms
A06-117	Spatial Registration for Forward-Looking Ground Penetrating Radar (GPR) With Magnetometer, Passive Millimeter Wave, Long-Wave Infrared, Medium Wavelength Infrared, Short Wavelength Infrared, or Visible Imaging Sensors
A06-118	High Coefficient of Performance Nano Cooler for Near Room Temperature Detectors
A06-119	High Performance Thermal Transfer Material
A06-120	High Efficiency Erbium/Ytterbium (Er/Yb) Doped Fibers for Eye-safe Fiber Laser Sources
A06-121	High Performance Uncooled Focal Plane Arrays
A06-122	Type I and Type II Superlattices for Tactical Applications
A06-123	Innovative Approaches to Service Organization Architectures for Legacy SIGINT System Interoperability with Global Information Grid (GIG)
A06-124	Innovative Architectures for Flexible Adaptive Communications Intelligence Analysis
A06-125	Seamless Route Distribution & Management Across Command and Control, Communications, Computers, Intelligence, Sensors and Reconnaissance (C4ISR) Networks
A06-126	Topology Design and Optimization Tool for Mobile Ad Hoc Networks
A06-127	Dual Band X/Ka On-The-Move Antenna System
A06-128	G-Hardened Radio Hardware Technology
A06-129	Programmable Waveform-Independent Digital Processor for Digital-RF Satellite Communications
A06-130	Spatially Combined Metamorphic High Electron Mobility Transistor Power Amplifiers for Satellite Communications
A06-131	Routing Protocol Design Toolset for Wireless Ad Hoc Networks to Maximize Quality of Service

A06-132	Curved Surface Electromagnetic Band Gap Metamaterial
A06-133	Multi-Mode Acoustic/Radio Frequency (RF) Techniques for Sensor Node Localization and Building Characterization

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

A06-134	A Man-Portable Fraunhofer Line Discriminator/Spectrometer
A06-135	Developing Automated/Semi-automated Techniques to Align Vector and Image Data
A06-136	Three Dimensional (3D) Topology Builder
A06-137	Enabling Cross-Domain Exploitation of a Common Geospatial Database
A06-138	Nanotechnology for Neutralization of Biowarfare Agents in Buildings
A06-139	Hydrogen Reformation of Renewable Ethanol for Military Applications
A06-140	Intelligent Tactical Electric Grid Control
A06-141	Monitoring Tire-Soil Interaction
A06-142	Detection of Vehicle Type and Buried IED's Through Remote Sensing
A06-143	Degradation Modeling of Composite Materials Used in Military Construction

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

A06-144	"Smart" Intermodal Shipping Containers
A06-145	Integrated Portable Explosives, Chemical Warfare Agent, and Radiation Detector

Joint SIAP System Engineering Organization (JSSEO) **Windy Joy Springs** **(703) 602-0901 (ext. 253)**
Christine Lee **(703) 602-6441 (ext. 278)**

A06-146	Association of Object Features and Attributes, with Limited
A06-147	Association of Critical, Infrequent Data

JPEO Joint Tactical Radio Systems (JPEO JTRS) **Kay Griffith-Boyle** **(732) 427-0634**
Grace Xiang **(732) 427-0284**

A06-148	Network Service Availability and Debug Technology
A06-149	Stateful Inspection Devices in an Asymmetric Routing Architecture

Medical Research and Materiel Command (MRMC) **Terry McCune** **(301) 619-2110**

A06-150	Inspiratory Impedance as a Treatment for Traumatic Brain Injury
A06-151	Ultrasound or Ophthalmodynamometry Technologies for Battlefield Diagnosis of Traumatic Brain Injury
A06-152	Insecticide Matrix Formulations for Improved Control of Sand Flies and Mosquitoes in Severe Environments
A06-153	Neural Protein Biomarkers in the Blood for the Diagnosis of the Severity of Brain Injury
A06-154	Pharmacological Strategies for Prevention and Treatment of Noise-Induced Hearing Loss
A06-155	Automated Laser Debridement System for Cutaneous Injuries
A06-156	Long-lasting Insecticide-impregnated Bed Net
A06-157	Liquid-Fueled Catalytic Heater for Infusion Fluids
A06-158	A Multiplexed Point-of-Care Assay for the Detection of Enteric Pathogens That Cause Severe Diarrhea in Deployed Soldiers
A06-159	Rapid Detection of Acetylcholinesterase-Inhibiting Pesticides in Water
A06-160	Diagnosis of Bone Fractures and Soft Tissue Injury with a Non-invasive Non-ionization Imaging Technique
A06-161	Multi-purpose Compressor-Decompressor (CODEC) with Telesurgery Capability
A06-162	The Role of Micronutrients in Reducing Noise-induced Hearing Loss
A06-163	Robotic Force Health Protection from Chem-Bio Agents and IEDs
A06-164	Dynamic Contrast Enhancing - Magnetic Resonance Imaging Agents for Angiogenesis Detection
A06-165	Micro Electronics for Intraoral Salivary Hydration Sensor
A06-166	Rapid and Early Detection of Prions
A06-167	Development and Automation of a Novel Dengue Neutralization Assay
A06-168	Wireless Sensor Network with Multiple Sensors for Chemical and Biological Threat Detection

Natick Soldier Center (NSC)		**Dr. Gerald Raisanen**	**(508) 233-4223**
A06-169	High Performance Lightweight Transparent Armor Materials		
A06-170	Development of Extruded Self Mating Closure System		
A06-171	High-Strength Low-Cost Polymer Fibers for Protective Clothing and Equipment, Shelters and Airdrop Equipment		
A06-172	Novel Textile Constructions for Puncture Resistant Inflatable Composites		
A06-173	Battlefield-Fuel Transpiration Membrane		
A06-174	High-Efficiency Heat Exchanger for Individual Stoves		
A06-175	Highly Conducting Textile Fibers for Electro-Textile Applications.		
A06-176	Wearable Electronic Network Made from Discrete Parts		
A06-177	Combined Heat and Power System (CHPS)		
A06-178	Development of Phage Technology Effective Against Biological Pathogens for Foods		
A06-179	UV Resistant Synthetic Polymer Fibers		
A06-180	Ethylene Control in Fresh Fruits and Vegetables		
A06-181	Pressure Measurement System for Parachute Fabrics And Other Textiles		
A06-182	Flow Field Measurements and Visualization for Full Scale Parachutes		
A06-183	Light Weight Fabric for Parachute Modeling		
A06-184	Agent Indicating, Decontaminable, Barrier Material for Protection Against Chemical and Biological Warfare Agents		
PEO Ammunition		**Robin Gullifer**	**(973) 724-7817**
		Jessica Woo	**(973) 724-4908**
A06-185	Wall Interrogator		
A06-186	Single Action Wall (SAW) Breecher		
PEO Aviation		**Rusty Weiger**	**(256) 313-3398**
A06-187	Continuous Power Assurance for Rotorcraft		
A06-188	Enhancing Computer Generated Forces (CGFs) for Air Traffic Control Interaction		
PEO Command, Control & Communications Tactical		**Kay Griffith-Boyle**	**(732) 427-0634**
		Grace Xiang	**(732) 427-0284**
		Brain Crawford	**(732) 427-3163**
A06-189	Reflective Cognitive Agents Supporting Faster than Real-time Course Of Action Analysis (COAA)		
A06-190	HMMWV Towable Load Following 100 kW Power Unit		
PEO Combat Support & Combat Service Support		**LTC John Shanklin**	**(586) 574-6228**
A06-191	Lightweight Mine-Protected Fasteners for Blast Protection Appliqués		
A06-192	Innovative Impact Energy Absorber Appliqué		
PEO Ground Combat Systems		**John Karavias**	**(586) 574-8190**
A06-193	Two-Phase Thermal Management Device Resistant to the Effects of Mechanical Vibration and Shock.		
A06-194	Complete Thermal Management Modeling Tool for System Integration of HVAC Systems		
PEO Intelligence, Electronic Warfare & Sensors		**John SantaPietro**	**(732) 578-6437**
		Rich Czernik	**(732) 578-6335**
		Debbie Pederson	**(732) 578-6473**
A06-195	Remote Control Improvised Explosive Device (RCIED) Low Band Jammer		
A06-196	High Power Ka/Ku Dual-Band mm-wave Power Amplifiers		
PEO Missiles & Space		**James Jordan**	**(256) 313-3479**
		George Burruss	**(256) 313-3523**
		Robin Campbell	**(256) 313-3412**
A06-197	Lightweight, Low Cost, Seeker Gimbals		
A06-198	Far Target Locator		

PEO Soldier — **King Dixon** **(703) 704-3309**
Ross Guckert **(703) 704-3310**

A06-199 Focusing a Thermobaric/High Explosive Blast Wave
A06-200 Articulated Soldier Knee and Elbow Protection System

PEO Simulation, Training, & Instrumentation — **Joseph Dorleus** **(407) 384-3806**

A06-201 Robust Single Frequency GPS Receiver Carrier Phase Measurements in a Mobile Ad Hoc Wireless Network

PM Future Combat Systems Brigade Combat Team — **Frank Duriancik** **(571) 281-4467**

A06-202 ICAS: Intelligent Control of Autonomous Systems
A06-203 UGV Dynamic Mobility Updates Using Real Time Prognostic and Diagnostic Information

Space and Missile Defense Command (SMDC) — **Dimitrios Lianos** **(256) 955-3223**

A06-204 Miniature Explosive Pulsed Power for Missiles and Munitions
A06-205 Solid State High Energy Laser Component Technology
A06-206 Automated Real Time Pose Determination
A06-207 Counter Mortar Technologies
A06-208 Innovative High Energy Laser Technology

Simulation and Training Technology Center (STTC) — **Thao Pham** **(407) 384-5460**

A06-209 Dynamic Integrated Video/Virtual View (DIV3)
A06-210 Predictive Technologies for Simulation and Training
A06-211 Reusable Synthetic Tissue for Severe Trauma Training
A06-212 Embedded Computer Generated Forces (CGF) Operator Control Unit (OCU)

Tank Automotive RD&E Center (TARDEC) — **Alex Sandel** **(586) 574-7545**
Martin Novak **(586) 574-8730**

A06-213 Abrasion/Shatter Resistant Transparent Armor
A06-214 Ultra-Light Weight Energy Absorbing Armor
A06-215 Imaging Radar for Small Unmanned Ground Vehicles
A06-216 Small Unmanned Inspection Vehicle with Manipulator Arm
A06-217 Light-Activated Instant-Blackening Optical Material
A06-218 Alternative Power Source for Small Unmanned Ground Vehicles
A06-219 Novel High-speed, Reliable, Non-mechanical Optical Switch
A06-220 Innovative Shape Memory Materials Process Techniques for Microelectronic Device Packaging
A06-221 A Fast Portable Hyperspectral Camera for the Detection of Camouflaged Objects
A06-222 Mobile Embedded Component Suite (MECS)
A06-223 Development of Federated Enterprise Architecture Models for Lifecycle Knowledge Management
A06-224 Multi-Physics, Multi-scale Ground Vehicle Reliability Prediction
A06-225 Advanced Fuel Injection System and Valve Train Technologies
A06-226 Demonstrate Novel Techniques to Manufacture Advanced Complex Three-dimensional Fuel Injector Nozzle Shapes to Improve Combustion Efficiency and Reduce Emissions
A06-227 Leap-Ahead Air Filtration Innovations and Technologies
A06-228 Research and Development Work to Optimize the Diesel Engine Design, to Operate at Greater than 42% Fuel Efficiency
A06-229 High Output Alternator Control System
A06-230 Magneto-Rheological Fluid Active Damper Suspension System for a Tracked Vehicle
A06-231 Electric Drive Running Gear System
A06-232 Shape Memory Alloy Reinforced Aluminum Foam composites for Ballistic Protection
A06-233 Advanced Military Cooling Designs and Techniques(AMCDAT)
A06-234 Piezoelectric Materials to Control Noise and Vibration and Detect Damage in Army Ground Vehicles
A06-235 Army Tactical Wheeled Vehicle Emulator for Improved Simulation Characterization and Reliability Assessment

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 25 pages or less in length. (Excluding the Company Commercialization Report.) Proposals in excess of this length 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. Requirement for Army Accounting for Contract Services, otherwise known as CMR reporting is included in the Cost Proposal.

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

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

____ 9. If applicable, the following information regarding a proposed Foreign Nationals has been included in the technical proposal - see section 2.15 of this solicitation for the definition. Use of foreign nationals shall require approval by the Contracting Officer. An employee must have an H-1B Visa to work on a DoD contract. If the offeror proposes to use a foreign national(s), the following information shall be provided: individuals full name (including alias or other spellings of name), date of birth, place of birth, nationality, registration number or visa information, port of entry, type of position and brief description of work to be performed, address where work will be performed, and copy of visa card or permanent resident card.

Army SBIR 06.2 Topic Descriptions

A06-001 TITLE: Autonomous Navigation and Obstacle Avoidance for Small Unmanned Aerial Vehicles without Global Positioning System

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop technologies that will ultimately enable small Unmanned Aerial Vehicles (UAVs) to navigate reliably in complex environments performing obstacle avoidance without reliance on Global Positioning System (GPS) or A Priori Data.

DESCRIPTION: One of the biggest challenges for autonomous UAVs is the ability to reliably navigate in complex terrain like urban jungles and near-earth environments. Several technologies exist for Unmanned Ground Vehicles, as evident from DARPA's Grand Challenge, and some of these can be transferred to UAVs. The problem is that most of these technologies are bulky and heavy and only apply to larger UAVs. Moreover these technologies tend to be slow, limiting the safe velocities at which UAVs can travel, and many approaches to navigation in complex terrain require precision GPS and significant amounts of a priori data (maps and 3D scans) to plan and navigate in real time. In addition, GPS and a priori data may not be always available. Small UAV's are the most appropriate and are agile enough to maneuver in these environments but have significant limits on payload. This makes sensors and processing to do robust navigation and obstacle avoidance a significant challenge.

This effort will investigate and advance the ability of current and developmental technology to permit small UAVs (both rotary wing or fixed wing) to navigate at low altitude in complex terrain and without GPS and with limited or no a priori data. Notionally this could use a priori data such as low resolution, terrain maps to identify areas of probable obstacles and then use real-time higher resolution visual (EO/IR, LADAR, SAR, etc.) and non-visual (RF, Acoustic, etc) data to identify stationary as well as moving obstacles in its path. The UAV should then be able to use this data to plan its near-term flight path autonomously. The navigation system onboard the small UAV should facilitate reliable deconfliction with other non-cooperative manned and unmanned aircraft.

The key technical challenges that will be the focus of this effort include:
1. Accurate state estimation without GPS updates in unpredictable flight conditions.
2. Low cost, low weight and low power sensor systems to detect obstacles.
3. Low latency data processing to enable autonomous flight at operational speeds.

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 navigation and obstacle avoidance in very complex environment without relying on GPS and a priori data. Conduct proof of concept assessment of any critical technologies.

PHASE II: Using simulation and other test facilities continue to develop and refine navigation and OA algorithm development. 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 goals and similar related DoD systems. This technology has potential commercial applications in the areas of intelligent transportation, underground mining 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, Obstacle Avoidance, Visual Odometry, Algorithms, GPS, Obstacle Avoidance, Algorithms, deconfliction, micro UAV

A06-002 TITLE: Rotorcraft Automated Load and CG Balance Measurement System

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Design, build, and demonstrate a Load and Center of Gravity(C/G) Balance Measurement System, applicable to rotorcraft platforms, which would eventually be integrated into the functionality of the aircraft onboard HUMS (Health & Usage Monitoring System).

DESCRIPTION: The development of an automated internal and external load weight and balance measurement system would provide a number of benefits that would be applicable to both new and legacy utility and heavy lift aircraft. An accurate and automated means for load determination is vital as a data input for HUMS-based parts lifing and damage algorithms. If the system could be readily integrated into current external lift and sling load handling systems, proven systems could be rapidly deployed to provide immediate safety benefits. They would also enable reduced cost of operation when integrated with HUMS systems within a condition-based maintenance environment (CBM). Accurate and automated load determination is currently unavailable, yet a crucial parameter for the aircraft HUMS. The HUMS utilizes this parameter to determine airframe loading and hence component life.

The concept must be capable of providing reliable measurement of internal and external load, to include external load amplitude and vector orientation while exposed to a full range of harsh operational environments, including temperature, sand, and sea spray. Current load management is done through manual estimates of internal and external loads that are manually converted to estimates of GW and CG. Internal loads can vary during flight through ejection/offload of payload or troops from external door and/or ramp area(s). External slung loads vary by aircraft and mission. Rescues may occur through cable winches via side doors. Payloads may be hooked to one or more releasable hooks. Many aircraft have two or three hook systems. Loads can be released in flight. Current aircraft have no internal or external load sensing capability for real-time GW or CG monitoring. The following functionality of a automated rotorcraft load and balance monitoring is desired:
• External load monitoring sub-system that includes either smart hooks and/or airframe attachment point sensors that can measure the amplitude and orientation of the external load vector(s).
• Internal load monitoring system that includes some concept for measuring the weight and distribution of internal cabin loads.
• Algorithm to automatically convert input from both internal and external load monitoring sub-systems into changes into overall aircraft load and balance.
• Display system to present real-time measurement of overall aircraft weight and balance relative to operational limits to the pilot.
The desired system concept would address both internal and external loads and CG monitoring.

PHASE I: The system will be designed, fabricated, and bread-board tested in a laboratory setting. Phase I testing will provide definite proof of concept for the technology. The system tested in the Phase I will address: 1)Automated load determination (internal and external) and 2)CG monitoring.

PHASE II: Further develop and demonstrate a prototype internal/external load weight and CG measurement system via more realistic bench testing. Bench testing will prove feasibility over extended real-world operating conditions. A minimum TRL=5 is expected at the end of the Phase II effort.

PHASE III: Phase III Military Application: After successful demonstration during Phase II, the UH-PMO may integrate and flight-test this technology in conjunction with the UH-60M Goodrich IVHMs diagnostic suite. The IVHMs has "open systems" software allowables where third party vendors could integrate their respective technologies into the Goodrich IVHMS(Integrated Vehicle Health Maintenance System) diagnostic platform. The UH-60 PMO is interested in furthering the benefits of Condition Based Maintenance(CBM) for the entire Blackhawk fleet and this topic would help facilitate this.

COMMERCIALIZATION: External/internal load calculation and CG control is vital for rotorcraft involved in logging, fire-rescue, natural disaster relief, ocean oil-rig logistics. For commercial rotorcraft with HUMS (eg. S-92), automated load calculation is still needed for lifing of parts and implimentation of true condition based maintenance(CBM).

REFERENCES:
1) HUMS Open Systems Specification, BF Goodrich Aerospace Aircraft Integrated Systems, DOC. NO. E-3424, 30 August 1999.
2) IEEE Std 1451.1-1999, Network Capable Application Processor (NCAP) Information Model.
3) AIAA-2000-4042, "On-line Identification and Nonlinear Control Of Rotorcraft/External-Load Systems", J. D. Schierman, T. H. Lawrence.

KEYWORDS: HUMS(Health and Usage Monitoring System),load measurement system, load cell, external/slung load(s), center of gravity balance, Condition Based Maintenance(CBM)

A06-003 TITLE: <u>Terrain/Obstacle Sensors for Rotorcraft Synthetic Vision Displays</u>

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: The objective of this SBIR topic is to develop a system of sensors and associated data processing to map terrain and obstacles around piloted and autonomous rotorcraft. For piloted rotorcraft, the data will be used to render terrain and obstacles on a helicopter pilot’s synthetic vision display to enable safe low level flight and landing during poor visibility conditions. Unlike current (radar) sensors on the MH-60K, this sensor system needs to be extremely short-range, very wide-field-of-regard, and high resolution. A multi-spectral solution (radar, laser, etc) may be required.

DESCRIPTION: The sensor system to be developed through this SBIR is intended to be used on manned and autonomous rotorcraft performing three maneuvers: 1) approach to a landing. 2) hover. 3) low level and contour flight up to 100 knots.

Landing: With the development of the UH-60M Coupled Flight Director and the UH-60M FBW FCS with Coupled Flight Director, the Army will have the stability and automated flight control systems to make landings in an all-weather environment. Unfortunately, obstacles and sloping terrain prevent landing in austere environments which are typical of combat/tactical environments. The development of lightweight/low power sensors to detect near field obstacles would allow the pilot to avoid obstacles in the landing environment even without visual reference to the ground. Note that SBIR topic A04-078 (Anacapa Sciences - CA) develops a display showing obstacle and slope for hover/landing, but not the sensor. Topic A04-078 suggests using a relatively new technique of building up a persistent database of obstacles and terrain, to enable an area to be scanned before a downwash dust cloud forms (which may prevent further high resolution scans), and also to reduce scan rate requirements. On the autonomous side, future UAV aircraft must scan an area before decision-making algorithms can identify best choice landing sites. Reference topic A05-066 (PercepTek – CO).

Hover: Both manned and unmanned rotorcraft need sensors to detect obstacles during hover. The aircraft can depart a hover in any direction, so a complete map of terrain/obstacles around a helicopter is required. However, the areas behind the rotorcraft may be displayed from the persistent database scanned previously during the approach-to-hover.

Low level and contour flight: On a synthetic vision display, an artificial image of the terrain is rendered from either a stored terrain database, or else sensor data. The pilot uses the perspective view image of the terrain to make decisions on the route to take over the terrain. In a combat environment, the desired route is below hill-top level, using valleys to mask the aircraft against radar detection. SBIR topic A03-070 (Monterey Technlogies - CA, Nav3D - CA, and AirEyes – OR) develops a system to merge (simulated) sensor and stored terrain database information, for the rendering of synthetic terrain on the primary flight display. Distant terrain is rendered from a stored terrain elevation database (since accuracy is not critical for distant terrain), while close terrain is rendered from sensor or sensor-checked data. This system corrects errors in the persistent, stored terrain elevation database, while keeping sensor power low (because only the close terrain is checked). For both manned and autonomous aircraft, the sensor system developed for this SBIR is needed to determine the terrain/obstacle heights in front of the aircraft at relatively short ranges (approx. 20 seconds in front of the aircraft). The ability to sense through particulates in the air (fog/snow/dust) is critical. However the resolution requirements are less than that required for landing and hover.

A single type sensor may not meet all the requirements. Radar will penetrate fog/snow/dust, but typically has insufficient resolution for hover/landing maneuvers. Laser has high resolution, but is adversely affected by particulates in the air, such as fog/snow/dust which limit its range. A hybrid system seems like a logical solution. However, single sensor solutions will be acceptable if the proposal addresses the requirements. Very wide fields-of-regard will be required both in the horizontal axis, and the vertical axis, possibly requiring sensor arrays. In the vertical direction, the sensor system needs to see obstacles below the aircraft, as well as in front of the aircraft. To reduce costs for this SBIR, less than idea fields-of-regard will be acceptable as long as the design is expandable in phase III. The goal is to be able to see at least 20 seconds in front of the aircraft, for any speed up to 100 knots. During hover/landing, the sensor system should detect obstacles as close as 1 rotor diameter away or less. This topic requires data processing electronics to covert raw elevation, azimuth, and range data from the sensors into a form that off-the-shelf terrain rendering software can import. Data processing should also remove noise (false signals) from the final output.

PHASE I: Phase I is a paper feasibility study. An industry and academia survey is appropriate for this phase of this SBIR. Deliver a phase I report on the feasibility of the system, with supporting evidence (if possible) that the system can be successfully build in phase II.

PHASE II: Design, fabricate, and laboratory test a prototype sensor system that meets the goals of this SBIR topic. Deliver a prototype system ready for flight test. Provide documentation necessary to integrate and operate the sensor system on a UH-60 aircraft. Deliver a phase II report on the design and test results of the sensor system.

PHASE III: If the cost and weight are low enough, there is potential to install this sensor system into every Army manned and autonomous airframe. This sensor system should reduce the number of helicopter accidents in marginal visibility conditions, and inadvertent IMC conditions, as well as enabling poor weather operations.

The number of Civil Emergency Medical Services (EMS) helicopter accidents can potentially be reduced from the proposed system. For EMS helicopter accidents between 1990 and 1999, a substantial 53% of accidents were at night, and 24% of accidents were during IMC conditions, both degraded visual conditions [Hart S. 2001]. Take-off, approach, and landing accounted for 19%, 16%, and 14% of all accidents, respectively. When the report includes all flight phases, in-flight collision with objects is the lead first event, followed by collision with terrain.

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1) Szoboszlay Z., Hardy G., Welsh T., “Improving the Flight Path Marker Symbol on Rotorcraft Synthetic Vision Displays,” American Helicopter Society Annual Forum, 2004.
2) Almsted L., Becker R., Zelenka R., "Affordable MMW Aircraft Collision Avoidance System," Enhanced and Synthetic Vision, SPIE Vol. 3088, 1997.
3) Zelenka R., Almsted L., "Flight Test of 35 GHz MMW Radar Forward Sensor for Collision Avoidance," First World Aviation Congress, 1996.
4) Coppenbarger R., "A Sensor-Based Automated Obstacle Avoidance System for Nap-of-the-Earth Rotorcraft Missions," Helmet Mounted Displays, SPIE Vol. 2735, 1996.
5) Fontana R., Larrick J., Cade J., Rivers E., "An Ultra Wideband Synthetic Vision Sensor for Airborne Wire Detection," Enhanced and Synthetic Vision, SPIE Vol. 3364, 1998.
6) Hellemann K., Zachai R., "Recent progress in mm-wave-sensor system capabilities for Enhanced (Synthetic) Vision," Enhanced and Synthetic Vision, SPIE Vol. 3691, 1999.
7) Holder S. Branigan R., "Development and Flight Testing of an Obstacle Avoidance System for US Army Helicopters," AGARD-CP-563, 1994.
8)Kretmair-Steck W., Haisch S., "All-weather capability for rescue helicopters," Enhanced and Synthetic Vision, SPIE Vol. 4363, 2001.
9) Wiley L., Brown R., "MH-53J PAVE LOW Helmet-Mounted Display Flight Test," Helmet- and Head-Mounted Displays and Symbology Design Requirements, SPIE Vol. 2218, 1994.
10) Craig G., Jennings S., Link N., Kruk R, "Flight Test of a Helmet-Mounted, Enhanced and Sythetic Vision System for Rotorcraft Operations", American Helicopter Society 58th Annual Forum, 2002.
11) Braithwaite M., Groh, S., Alvarez E., Spatial Disorientation in US Army Helicopter Accidents: An Update of the 1987-1992 Survey to Include 1993-1995, USAARL Report No. 97-13, 1997.
12) Durnford S., Crowley J., Rosado N., Harper J., DeRoche S., Spatial Disorientation: A Survey of U.S. Army Helicopter Accidents 1987 - 1992, USAARL Report 95-25, 1995.
13) Hart S. G., “Civil Medevac Accidents,” 11th International Symposium on Aviation Psychology, Columbus OH, 2001.
14) "Aircrew Training Manual Utility Helicopter, UH060, EH-60," US Army Training Circular No. TC 1-212, 1996.

KEYWORDS: helicopter, rotorcraft, radar, LIDAR, synthetic vision, sensors, landing, survivability

A06-004 TITLE: Unmanned Aerial Vehicles Launch and Recovery On the Move (UAVLR-OTM)

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop a small self-contained Unmanned Aerial Vehicle (UAV) Launch and Recovery On the Move (UAVLR-OTM) system that can be mounted on a variety of military vehicles (HMMWV, tanks, trucks, and other UGVs) that are moving at significant velocities over potentially very rough terrain. This technology should be equally applicable to marine applications in the Navy and commercial fleets.

DESCRIPTION: One of the key to aspects behind the FCS Class 2 UAVs is the ability to be launched from a variety of vehicles. In order to not hamper the mobility of the FCS Company or platoon vehicles and maintain the OPTEMPO of the mounted forces, it is desirable that the UAVs be able to do autonomous take-offs and landings on the move. Ideally such a system would be small and compact enough to mount on a variety of manned and unmanned systems likely to be developed under FCS as well as be able to be retrofitted on trucks and other vehicles. Moreover such a system would support automated refueling and rearming. Although many people are developing launch and recovery capabilities from a variety of vehicles, the major technical challenge comes from doing it on the move at a significant speed. Much like in naval automated take-off and landing systems for helicopters, the difficulty in landing on a platform that can be moving in 3D is extreme and when combined with the obstacles associated with operating in urban environments and other complex terrains becomes a technology challenge in search of an innovative solution.

This effort will focus on addressing the key technical challenges associated with doing the launch and recovery on the move and not the packaging and support capabilities (refueling, maintenance) of the entire module. The key technologies to be addressed in this effort include:
1. Terminal guidance system capable of synchronizing movements of the vehicle and the UAV.
2. A means for assessing obstructions in the vicinity and its projected path of the platform.
3. The ability to secure and release the UAV on the move reliably without damaging it.

To be applicable for UAVLR-OTM, the technologies must also have the potential to fit in a small mountable package on the ground vehicle, minimal impact on UAV payload and functionality, have realistic power requirements, and must be able to be engaged remotely and be fully autonomous relative to the launch and recovery operation. Prime concern in this effort needs to be the safety of the manned vehicle and the potential impact on bystanders.

Besides being used on ground vehicles, this type of system would have direct application to naval vessels and would pave the way for ultimately developing a airborne launch and recovery.

Although this effort will focus on the key launch and recovery sub components, a complete concept or a mobile UAV platform would also include capabilities for refueling and rearming, act as a maintenance platform for the UAV in the field to include automated diagnostics, and provide the opportunity to shield the UAV while mounted on the platform. Although it is desirable to develop a general solution UAVLR-OTM applicable to all UAVs, it is understood that the physical and technical aspects of a UAVLR-OTM concept are likely to limit the applicability of the system to UAVs with certain characteristics.

For this effort, the offerer is free to consider concepts applicable to either fixed-wing or rotary-wing UAVs and air vehicle up 130 lbs gross weight. Flight characteristic (speeds and physical dimensions) of the UAV need to be consistent with landing on a moving vehicle. Concepts applicable to smaller UAV as low as a few tens of pounds would also be of interest.

PHASE I: Trade study to find and assess appropriate technologies to perform the terminal guidance, path clearance and capture/launch the UAV from a moving vehicle. The trade study will consider a range of application ranging from: 1) speed up to 25 miles per hour on uneven and winding terrain to 2) improved roads in urban and residential community with speeds up to 45 miles per hour. The contractor shall develop an integrated concept for the UAV Launch and Recovery On the Move (UAVLR-OTM) system. The contractor shall conduct proof-of-concept studies and/or limited demonstrations to validate critical components of the design.

PHASE II: Using simulation and other test facilities continue to develop and refine navigation and UAVLR-OTM algorithm development. Design and develop a complete UAVLR-OTM system, install it on a small military vehicle or surrogate, and conduct testing to characterize system performance. Use the demonstration results to develop a system specification and expand and refine the design for a complete UAVLR-OTM module including packaging, mounting, and UAV support capabilities (refuel).

PHASE III: The of UAVLR-OTM has direct applicability to several FCS and other DoD systems. UAVLR-OTM supports border patrol, police, oil line surveillance and forest fire protection. This technology could enable a vast assortment of new and unanticipated applications of UAV technology in both the commercial and military domains.

REFERENCES:
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KEYWORDS: UAV, Launch, Recovery, vehicle, On-the-Move, FCSUAV, Autonomous, Navigation, GPS, Obstacle Avoidance, Algorithms, Cooperative flight, terminal guidance

A06-005 TITLE: Design and Development of an Inter-Turbine Burner for Turboshaft Engines

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop and validate an inter-turbine burner for use in a turboshaft engine to provide improved part power performance.

DESCRIPTION: Advanced turboshaft engines are expected to be required to support future Army Unmanned Air Vehicle (UAV)/Future Force Systems (i.e., A160, Future Combat System, Joint Heavy Lift, Future Utility Rotorcraft). Future missions will require these systems to spend a significant amount of time at cruise (part power) conditions with the objective of increased range and time-on-station. Therefore, the advanced turboshaft engines of the future will be required to provide significantly improved performance at part power in order to support these missions. A reheat cycle in which heat is added between the high pressure turbine and the low pressure turbine (power turbine) of a turboshaft engine has shown great potential for improved part power performance. A second combustor or “inter-turbine burner” provides the heat addition between the turbines. One potential use of this configuration allows the main combustor to be designed for optimum performance at part power. The inter-turbine burner would then be used to supply added power during takeoff and evasive maneuvering. Several other usage spectrums may exist with this configuration to optimize part power performance. Although the objective of this topic is the development and validation of the inter-turbine burner, offerors are encouraged to consider the inter-turbine burner and the main combustor as a system during their design. Doing so may provide opportunities to significantly reduce engine weight and length. The burner design should be compact and minimize pressure loss. Offerors should also consider the effect of heat addition on the power turbine life during the design. Teaming with major engine manufacturers is highly encouraged in order to identify potential engine size class and prepare for commercialization in the future. A successful demonstration of this topic will result in advanced Objective Force rotorcraft that can operate in a robust manner over a large power range for both cruise and full power conditions.

PHASE I: Perform the preliminary design of a compact, low pressure loss inter-turbine burner for use in turboshaft engines and demonstrate feasibility. The preliminary design should consider effects on the power turbine and the ability of the inter-turbine burner to function as a system with the main combustor.

PHASE II: Complete the detailed design, fabricate, and conduct validation testing on a prototype inter-turbine burner. Validation testing should involve a rig test which simulates a representative engine environment (representative inlet flows and temperatures and representative inter-turbine burner geometry).

PHASE III: The commercial potential for this technology is high. The benefits of the inter-turbine burner concept are not limited to UAV propulsion. The reheat cycle could also improve the performance and/or power output of larger turboshaft engines as well as turbofan engines used in both military and private industry. In the third phase of this topic the offeror should focus on the commercialization of the technology through refinement of the technology and integration into engine an manufacturer’s propulsion systems for use in future engine development programs.

REFERENCES:
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2) Zelina, J., Ehret, J., Hancock, R. D., Shouse, D. T. and W. M. Roquemore 2002 “Ultra-Compact Combustion Technology Using High Swirl For Enhanced Burning Rate”, AIAA-2002-3725, AIAA Joint Propulsion Conference.

KEYWORDS: Inter-turbine burner, combustor, combustion, turboshaft, engine, ITB, UCC, Ultra Compact Combustor

A06-006 TITLE: <u>Low Reynolds Number, High-Lift Airfoil Development for Vertical Takeoff and Landing Uninhabited Aerial Vehicles (VTOL UAVs)</u>

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: The primary objective of this project is the development of radically new high-lift, low-pitching moment airfoils for Vertical Takeoff and Landing Uninhabited Aerial Vehicles (VTOL UAVs). This is to be performed with a solid engineering approach where high quality measured airfoil data is acquired specifically for the challenging VTOL UAV aerodynamic environment.

DESCRIPTION: In support of soldier operations in hostile environments, VTOL UAVs are a rapidly emerging class of vehicle with a range of sizes and mission profiles. Examples are soldier portable ducted fans, hand launched conventional helicopters, and larger VTOL UAVs such as the A-160 Hummingbird. One challenge common to all VTOL UAV rotor designs is the performance penalty caused by low Reynolds number aerodynamics. For small vehicles, such as the portable ducted fan, the rotor blade chord size results in Reynolds numbers in the range of 50,000 to 250,000. For the case of larger UAVs, such as the A-160, the retreating blade Reynolds number at high altitude can easily fall below 500,000. The demands on these types of aircraft and their importance to wartime operations requires a better understanding and development of high performance airfoil designs and well validated design/analysis tools in the range of Reynolds numbers from 50,000 to 500,000. It is in this range, where flow physics issues associated with laminar separation bubbles prevent accurate numerical simulation of new designs. In the case of micro air vehicles, where Reynolds numbers can be in the range of 1000 to 20,000, the physics involve laminar separation without reattachment in most cases. This creates less of a challenge for Computational Fluid

Dynamics tools to model transition, although this is still an important area of research. The current focused effort involves a range of Reynolds numbers from 50,000 to 500,000 that covers small low-altitude portable UAVs and high altitude larger UAVs that are likely to be deployed in the near term.

Improved airfoil designs can impact mission effectiveness by improving performance in terms of hover figure of merit, and cruise lift to drag ratio. These improvements result in increased payload, range and endurance of the UAV platform. The major challenge for VTOL UAVs is to achieve high-lift airfoil performance without generating high pitching moments. The constraint on pitching moment requires a truly innovative design in order to prevent excess vibration, dynamic instabilities, and elastic deformations when the concept is applied to a rotor blade. While much research in academia and industry has focused on fixed wing low Reynolds number airfoil performance, great innovation will be required in this project to further the understanding of how separation bubble flow physics change in the rotor environment. Challenges of the rotor environment arise from a greater number of potential triggers for boundary layer transition. Examples include cross flow instabilities from yawed flow, vortex wake induced freestream turbulence, and high frequency elastic deformations. Any new design must be able to either adapt or be immune to major changes in the transitional nature of the rotor blade boundary layer.

PHASE I: The Phase I work involves development of a 2D wind tunnel testing approach/technique focused on rapid prototyping of airfoil models, measurement accuracy, and a fast turn-around time. This would include the identification and measurement of a high quality baseline test case with comparisons to other test facilities and the current state-of-the-art design/analysis tools. Measurements should include both tripped and untripped lift, pressure drag , total drag, and pitching moment, as well as measurements of transition location. The Phase I effort would provide a framework and justification for the facilities and methods used in the study in the context of VTOL UAVs, and low Reynolds number aerodynamics. The effort would conclude with a selection of airfoils for Phase II, and the identification of any unique high lift rotor airfoil concepts for future evaluation in Phase II.

PHASE II: The Phase II task begins with detailed wind tunnel measurements on a representative group of high priority VTOL UAV airfoils using the methods and facilities developed in Phase I. The task continues with the validation of design/analysis tools using the wind tunnel measurements with special emphasis on the detailed flow physics limiting current high-lift performance. Once validated, the semi-empirical tools would be used to establish state-of-the-art performance bounds. These newly developed tools should be compared to current efforts of using Computational Fluid Dynamics for capturing laminar separation bubble flow physics over this Reynolds number range. Properly validated tools would enable the design of an advanced high-lift airfoil concept for follow-on wind tunnel testing. Such a concept must achieve high-lift performance without creating a large pitching moment unsuitable for use on a rotor blade. At the conclusion of Phase II, this radically new concept would be sufficiently matured to justify further evaluation by the US Army or Industry in a rotor aero-performance test.

PHASE III: The military application of this technology can be applied to the development and improved performance of high altitude VTOL UAVs, micro air vehicles, and fixed wing UAVs. In some cases, a radically new level of airfoil performance using a unique concept can lead to the development of an entirely new class of military vehicle. The commercial applications of the research include the development of well validated design/analysis tools for industry, novel high lift concepts for aerodynamic performance, advanced wind energy technology, and fixed wing transport efficiency.

REFERENCES:
1) Maughmer, Mark D., and Somers, Dan M., "Design and Experimental Results for a High-Altitude Long-Endurance Airfoil", Journal of Aircraft, Vol. 26, No. 2, Feb. 1989, pp. 148–153.
2) Eppler, Richard: Airfoil Design and Data. Springer-Verlag (Berlin), 1990.
3) Drela, Mark, "XFOIL: An Analysis and Design System for Low Reynolds Number Airfoils" Low Reynolds Number Aerodynamics, T. J. Mueller (ed.), Lecture Notes in Engineering, Vol. 54, Springer-Verlag Berlin, 1989, pp. 1–12.
4) Martin, Preston B., "Rotor Blade Airfoil Design for High-Altitude, Long Endurance VTOL UAVs," 31st European Rotorcraft Forum, Florence, Italy, 13-15 Sept. 2005.
5) Martin, P. and Tung, C., "Performance and Flowfield Measurements on a 10-inch Ducted Rotor VTOL UAV," Proceedings of the 60th Annual Forum of the American Helicopter Society, Baltimore, MD, June 7-10, 2004.

KEYWORDS: airfoil, aerodynamics, rotorcraft, UAV, VTOL, Reynolds number, wind tunnel testing

A06-007 TITLE: Delegation of Authority to Intelligent Unmanned Aerial Vehicle (UAV) Team Members

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop an intelligent network-centric control solution that allows an operator to delegate, or assign predetermined tasks, to Unmanned Aerial Vehicles (UAVs) or teams of UAVs. This will free the operator up for higher order strategic decisions. The supervisory control and overall responsibility, however, stays with the operator.

DESCRIPTION: A great deal of effort has recently focused on the development of autonomy for UAVs. These include Autonomous Collaborative Operations (ACO), UCAR, DARPA's HURT, and the Navy's Intelligent Automation. These enabling technologies as well as desires to reduce the operator: vehicle ratio leads to the need for operators to serve more as supervisors to intelligent UAVs, and less as remote pilots of a single platform. The supervisory control of UAVs is the other side (and the human interface side) of the automation coin.

However, human interaction with automation through supervision is difficult to optimize. It is a difficult technical problem to develop an interface that optimizes the use of multiple sensor views, for example. Several issues have been identified in literature largely based on fixed wing commercial aviation.

Mode awareness. A major concern regarding human-automation interaction has to do with mode awareness. Too many examples are available that show crews taking an action that would be correct in one mode, but that leads to problems in the present mode (Degani, 2005). Consider the tragic example of Korean Airlines 007. This flight from Anchorage, Alaska to Seoul, South Korea ended in a tragedy that was a confluence of many factors, but the initiating cause was mode awareness. The pilots were in heading hold mode, which keeps the aircraft on the generally correct, heading within 15 degrees. This is adequate for short distances, but as will be seen the error grows dangerously large over longer flights. The pilots switched the mode control panel from heading hold to the more accurate inertial navigation system (INS). However, entry into INS mode requires satisfaction of two conditions. The aircraft needs to be within 7.5 miles of the route and pointed in the general direction of the route. One of these conditions was not met. The aircraft, therefore, never entered INS mode. Over thousands of miles, the aircraft drifted 200 miles off course into airspace controlled by the USSR and the event ended with disastrous consequences. The initial cause of this accident was the pilots misunderstanding of the control modes. Clearer enunciation and more intuitive control of the modes are essential to making the automation more useable and error tolerant.

Out of the loop. In a highly automated system, the operator may be asked to monitor a number of processes. If the automation controlling these processes is largely successful and failure rates are low, the operator may not need to monitor very closely. This can lead to the operator being out of the loop when a failure does occur. Recognizing that a failure has occurred and getting back the situational awareness needed for diagnosis can take a critically long time. This concern is especially prevalent for "semi-autonomous" systems, in which the system is highly automated without a human in the loop, until something goes wrong. The role of the human is then to quickly assess the situation and take corrective action. But, having been out of the loop, this task is much more difficult. Lee and Moray (1994) have called this Out Of The Loop Un-Familiarity.

Knowledge of Automation State. Highly related to being out of the loop is knowledge of automation state. In order for the operator to team with the automation, he/she needs to know what the automation is doing and why. The automation needs to be transparent and not a "black box." The lack of this knowledge will lead to mode awareness problems, under utilization, high workload in trying to determine what the automation is doing and poor situation awareness.

Over reliance. Automation bias can come in two forms, over reliance on automation and under reliance. Over reliance, also called complacency, takes place when operators trust the automation to the extent that they no longer cross check what it is doing, and blindly accept its direction. An example of complacency was discussed by Azar, 1998. A Panamanian cruise ship, Royal Majesty, was off the coast of Nantucket. The ship was being controlled by a satellite navigation system, which failed. Several other sources of navigation information were correct and available to the crew. These however, went unmonitored and as a result the ship ran aground.

Under reliance. Automation can also be biased toward under reliance. High false alarm rates in the early design of the Ground Proximity Warning System (GPWS) led pilots to disable the system and turn off the automation. This has also been called automation disuse by Parasuraman and Riley (1997).
These types of issues and concerns highlight the criticality and technical risk of developing a human-automation interface. One innovative method to supervise UAVs is through delegation.

Delegation is an approach by which operators can interact with intelligent entities, in this case UAVs, by delegating, in a pre-determined fashion, authority for certain actions to UAVS. Parasuraman, Galster, Squire, Furukawa, and Miller, (2005), Miller, (2005), Miller, Funk, Goldman, Meisner, and Wu, (2005), Miller, Goldman, Funk, Wu, and Pate (2004) & Miller, Pelican, & Goldman, (2000).

Imagine a UAV operator in control of a flight of four UAVs. The UAVs are on a reconnaissance mission to a named area of interest (NAI) “alpha”. The operator gets information that a manned ground unit is being fired upon. The operator can task UAV1 with a high-recon mission to gather information about that nature of the threat and locations. The tasks of deciding and monitoring altitude, airspeed, loiter pattern, and even actions on contact can be delegated to the system.

UAV2 might be tasked with flying a lower level loiter pattern to look for possible avenues of egress, also with the basic flight parameters delegated. While the operator is still in charge of these UAVs, they have been delegated certain predetermined tasks that will reduce the operators workload and increase his/her ability to complete such a complex mission. While these are re-directed UAV3 and UAV4 can complete the mission to “alpha”. With current interfaces, the operator would have to enter a number of commands; change way-points, enter loiter coordinates, altitudes, etc. However, if the operator has pre-determined taskings, he can delegate a number of these details to the UAV.

The operator maintains supervisory control and awareness of the UAVs actions and intentions. Any interface design should take this human-centered philosophy into account. Delegation will make more efficient use of limited resources of the UAV and reduce the workload of operators to free them up for strategic planning. Applied to a network or team of UAVs, this concept will allow effective, efficient control of multiple, heterogonous UAVs.

PHASE I: Develop an architecture, rules, language, algorithms and interface to the users to apply a delegation scheme to Army UAVs. An evaluation methodology is needed to clearly differentiate the performance of such a system versus current practices.   The target for this effort will be US Army assets, and the planning should reflect this. This may require an understanding of Army UAV operations as currently practiced as well as the capabilities of the Army UAV fleet.

This system should be defined and if possible, instantiated in simulation in Phase I.

PHASE II: Develop a prototype of the system defined in phase I with application to US Army tactical situations and UAV platforms. The prototype will instantiate the architecture including the language of interaction, and the operator interface. This will include the definition of missions, platforms, tasks to be delegated, as well as the rules and methodology for delegation.

The prototype should be tested with Army UAV operators in simulation and demonstrated in flight test. This evaluation phase should demonstrate overall improvements in system performance as well as individual user workload, performance and situational awareness.

PHASE III: The system described above would have potential commercialization to other DoD organizations that operate UAVs; the US Air Force, Navy and Marines. In addition, the Department of Homeland Security and within DHS, the Border Patrol and Coast Guard are potential consumers of this type of delegation system. However, perhaps the largest potential market is the civilian UAV operations that, with FAA certification of UAVs, could expand exponentially and be a very large market for this technology.

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Miller, C., Funk, H., Goldman, R., Meisner, J., and Wu, P. (2005). Implications of Adaptive vs. Adaptable UIs on Decision Making: Why "Automated Adaptiveness" is Not Always the Right Answer. In Proceedings of the 1st International Conference on Augmented Cognition, Las Vegas, NV; July 22-27.

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KEYWORDS: UAV, delegation, supervisory control.

A06-008 TITLE: Advanced Inlet Protection System in Severe Sand Environments

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop and validate an inlet protection system for gas turbine engines. Innovation should be present in the design of the inlet protection system. Meeting performance goals and overcoming the additional challenges inherent with this technology are paramount. The most significant performance goal is to achieve a 97% separation efficiency with minimal pressure drop on A2 fine grade test dust which is defined as follows:

Per ISO 12103-1, A2 Fine Grade Test Dust (crushed quartz):

Microns Percent

0-5	31-36
5-10	14-23
10-20	16-24
20-40	14-21
40-80	8.5-12

Additional challenges include, but are not limited to, weight and volume reduction, improved aerodynamic performance, and improved performance in an icing environment all relative to existing operational systems. It is also desired that an evaluation of performance degradation over time be executed and validated for both mission specific (desert environments) and non-mission specific (ice and FOD) operations.

DESCRIPTION: Continuing operations in sand environments have created an immediate need for improvement upon existing inlet protection systems. Ongoing technological development is essential to the success of operations in sand environments. Ingestion of both coarse and fine sands severely impacts the performance of gas turbine engines. Ingestion of coarse sand particles can cause severe erosion of compressor and turbine components. This erosion, which can occur in as little as 20 hours [1], can cause severe performance degradation and even engine failure. The engine may also have complications due to sand contamination of the lubrication systems causing blockages and failures of said system. Ingestion of fine sand particles does not significantly contribute to erosion of machinery but can cause issues in the hot section of the engine. As the fine particles enter the hot section they can melt and then solidify on the turbine blades, which can adversely affect the aerodynamic properties of the turbine, which degrades the performance of the engine.

In an effort to reduce the amount of coarse and fine sands to a desirable level it is requested that a system be developed to ensure that not only the coarse sands are removed but also the fine sands. A sound yet innovative configuration is desired to achieve this level of performance. The challenges facing this endeavor are maintaining an optimal pressure loss across the inlet protection system as well as maintaining performance over time as the systems' properties may change in a desert environment. Additional challenges to be addressed include the ability of the integrated system to: 1) perform effectively when operating in an icing environment and 2) effectively eliminate/minimize foreign object damage (FOD). The benefit of this technology will help to ensure success of missions in desert environments such as Afghanistan and Iraq as well as increase maintainability by reducing maintenance time and requirements.

PHASE I: Develop a design for the advanced inlet protection system and present the feasibility of the design relative to achievement of topic objectives. This would involve feasibility demonstration via modeling of the system performance or basic proof of concept test.

PHASE II: Design and develop the proposed advanced inlet protection system (preferably via coordination with an engine or airframe manufacturer) and validate the performance relative to topic goals through experimentation. This should involve a rig test of the inlet protection system at representative engine inlet flows where sand quantities going into system, sand quantities separated by system, and sand quantities that are not captured/separated by the system are measured.

PHASE III: Refine and validate the design via rig test for integration into specific manufacturer's engine or air platform focusing on commercialization of the system technology. The resulting effort will be applicable to both military and commercial applications as both conduct operations in sand environments.

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2) "AN OVERVIEW OF INLET PROTECTION SYSTEMS FOR THE ARMY AIRCRAFT", Raymond T. Higgins and David B. Cale, Aviation Applied Technology Directorate, presented to the Rotory Wing Propulsion Specialists' Meeting, Williamsburg, VA November 13-15, 1990.

KEYWORDS: Gas Turbine Engines, Sand Ingestion, Filters, Inlet Particle Separator, Inlet Barrier Filter, Sand Environment, Particle, Separation

A06-009 TITLE: Rapid Computational Fluid Dynamics (CFD) Methodology for Rotorcraft ManeuverAnalysis

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop and/or adapt reduced fidelity CFD aerodynamics methodology applicable for rapid and efficient engineering analysis of rotor blade loads and flight dynamic characteristics of rotorcraft in maneuvering flight.

DESCRIPTION: Rotor blade and control system loads during maneuvering flight typically define the most severe structural loads in the flight envelope of rotorcraft and thus determine the structural design requirements for the aircraft. Current comprehensive analysis codes, Ref. 1, based on lifting line methods, vortex wakes, and approximate methods for aerodynamic interference between the rotor, fuselage, and empennage are incapable of predicting these loads with accuracy sufficient for design purposes. This leads to excessive design conservatism with attendant weight penalties and reduced mission performance. Furthermore, the complex flowfield interactions among rotorcraft components makes it very difficult for current comprehensive codes to accurately predict rotorcraft flight dynamics and control characteristics in steady state as well as maneuvering flight. Application of first principles computational fluid dynamics (CFD) methodology is being brought to bear on these problems but this approach will be very computationally intensive, particularly when using tight coupling algorithms for combining CFD and computational structural dynamics (CSD). A very attractive alternative would be to combine reduced fidelity CFD methods with comprehensive analysis codes using current CFD/CSD tight coupling algorithms, Ref 2. This would produce a very attractive design capability having high levels of accuracy and computational efficiency, along with the ability to model arbitrary vehicle and structural configurations. These capabilities would then enable applications by industry for the rotorcraft design process and by government organizations for analysis of upgrades and field support. One candidate rapid CFD approach is to use momentum disk (time averaged) or momentum source (unsteady) approaches to model the rotor blade force and flowfield interface for the CFD analysis. Equivalent CFD approaches would be appropriate provided they afforded sufficient accuracy and computational efficiency while replacing conventional lifting line and vortex wake analysis methods. The CFD aerodynamic model would be coupled with a suitable existing government-provided rotorcraft comprehensive analysis code to model the non-aerodynamic parts of a complete rotorcraft simulation.

PHASE I: Develop an overall rotorcraft analysis methodology for a coupled CFD/CSD system based on reduced fidelity CFD methods and a government-provided rotorcraft comprehensive analysis code. Include a description of the coupling algorithm. Provide a top-level software design for such a system. Provide preliminary example aerodynamic results for the uncoupled system. That is, for representative prescribed steady and maneuvering flight conditions (for specified rotor and blade motions), predict rotor blade airloads and fuselage airloads for the vehicle.

PHASE II: Based on the top-level system design produced in Phase I, complete the detailed design for the software of the coupled CFD/CSD system. Following the detailed design, implement the associated software modules. Integrate the software modules in the comprehensive analysis. Test the integrated software and generate representative results for steady and maneuvering flight conditions. Compare results with representative flight test data for these same flight conditions. Prepare appropriate test reports and software documentation for the developed code.

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

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

KEYWORDS: CFD, rotorcraft aeromechanics, maneuver flight, joint heavy lift

A06-010 TITLE: Assembly of Ceramics/Ceramic Matrix Composite (CMC) Components

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop an effective method of joining Monolithic Ceramic or Ceramic Matrix Composite (CMC) components to adjacent CMC and/or metal components to form reliable separable and inseparable assemblies. Attachment schemes of Ceramics/CMC's would help the advancement of new Ceramic/CMC technologies in turbine engines. The use of Ceramic/CMC's will increase efficiencies, increase rotor inlet temperature and decrease cooling flow which will in turn reduce Operating and Support (O&S) costs for future helicopters.

DESCRIPTION: Innovative technologies are required for advancing rotorcraft development. There is a need for lighter, stronger and higher temperature resistant materials for use in advanced turbine engine components. Many upcoming engine programs such as Advanced Affordable Turbine Engines (AATE) and Joint Heavy Lift (JHL) will be incorporating Ceramic/CMC technologies into their engine development plans. Ceramic/CMC's are a key technology for advancing turbine engine component designs. They are capable of replacing metal components to operate in significantly higher temperature environments and will require less air for cooling. However, before these components can be truly beneficial, robust attachment schemes (both permanent and mechanical) need to be developed and perfected. The attachment concept must address differences in thermal expansion coefficient between the CMC and metallic components and the fracture properties of CMC's. The selected method will have properties approaching parent material at engine operating conditions.

PHASE I: Develop and prove the feasibility of the proposed Ceramic/CMC attachment approach or approaches (working with a gas turbine engine manufacturer is encouraged). The demonstration shall validate the feasibility of the proposed technology.

PHASE II: In conjunction with a gas turbine engine manufacture and utilizing the results from Phase I, optimize the Phase I design and fabricate components for testing. Scale up proposed method by producing full scale simulated components suitable for more extensive property and functional testing in relative environment.

PHASE III: Focus on the commercialization of the technology through integration into gas turbine engine manufacturer's design system for use in current and future development programs.

COMMERCIALIZATION: Ceramic materials have potential to improve turbine engine performance and cost for both military and commercial applications. Advanced ceramic attachment schemes/technologies should have multiple applications outside the turbine engine industry (automotive, structures, etc.).

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KEYWORDS: CMC, Ceramics, Gas Turbine Engines, Attachments, Assemblies

A06-011 TITLE: Wireless Pressure Transducer

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: The overall objective of the study is to develop an innovative wireless micro-sensor system for pressure measurements on helicopter blades and provide a proof-of-concept through prototyping and experimentation.

DESCRIPTION: Current techniques used to measure on-blade dynamic pressure vary from piezoresistive sensors to non-intrusive methods that make use of pressure sensitive paints. At present, a widely developed technique for unsteady pressure measurements is based on piezoresistive silicon sensors (such as Kulite LQ-47 sensors). Although the performance of such sensors has been improved considerably, they are inherently susceptible to electro-magnetic interference, temperature drift, and hysteresis. Due to the sensor wiring and weight limitations, tremendous effort is needed to do the following: i) designing and building an expensive custom blade that ends up being heavier than scaled, ii) getting the wires into the hub, and iii) creating a complicated hub package and signal conditioning system in the rotating frame. For these reasons, even adding a small number of sensors to an existing blade becomes complex and expensive. Pressure sensitive paints enable non-intrusive measurements of two-dimensional pressure distributions over a test model surface. A luminescent component in the paint is excited optically and subjected to pressure-dependent quenching by oxygen in the flow, which can be detected and processed on the basis of either intensity or decay time. However, this technique has limitations of pressure resolution, bandwidth, sensitivity to temperature variations, and being suitable only for laboratory studies. Considering the importance of on-blade pressure sensing in modern rotorcraft, it is imperative to develop a new sensing technology for such a purpose. For example, optical fiber pressure sensors based on Fabry-Perot interferometer (Ref.1) have a number of potential advantages in comparison to their electrical counterparts, and these advantages can be leveraged to carry out in-situ pressure measurements on rotating blades. These sensors are in the same size range as MEMS sensors, immune to electro-magnetic interference effects, electronically passive, and multiplexible.

PHASE I: This phase begins with the analysis and identification of various approaches to solving the problem of developing a robust light-weight wireless sensor. Background research would include theoretical modeling as well as practical demonstrations of different candidate technologies. From the initial research, the most promising technologies would be selected to demonstrate the implementation of the new sensing technology to measure rotor blade surface pressure. The Phase I research would conclude with an analysis of the survivability and measurement accuracy of the candidate technology in the form of bench top demonstrations. Deliverables would include the characterization of signal to noise ratio, resolution, accuracy, temperature/vibration sensitivity, frequency response, and measurement uncertainty. The status of the project at the end of Phase I should be sufficient for the follow on development required to produce a prototype system in Phase II.

PHASE II: Using the experience and techniques developed in Phase I, the critical components would be integrated into a prototype system. The system would be installed on a rotor blade for checkout testing to verify that functionality and survivability in the harsh rotor environment. This proof-of-concept pressure sensor system would be used to validate the predicted measurement accuracy, system integration, wireless communications, and sensor integrity. The chordwise pressure distribution at several radial stations would be measured on the rotor blade in hover, and the data would be compared to conventional pressure sensors at a few leading edge locations. A small subset of the system would then be flight tested on the horizontal T-tail of a helicopter in cruise to verify performance in the unsteady rotor wake environment. This demonstration would provide the necessary proof-of-concept to enable the system to enter a commercialization phase.

PHASE III: The benefits of a wireless pressure transducer system that is flight worthy and also accurate enough for high fidelity wind tunnel testing would create a large market of customers. This would include rotary wing, fixed wing, and space launch sectors of the aerospace industry. The use of wireless pressure sensors could enable warning systems for both civilian and military aircraft in the event of adverse aerodynamic conditions such as stall, vortex ring state, or other flight boundaries. The rapid identification of aerodynamic sources of rotor performance limits, interactional flow induced vibration, tail buffet, or acoustic signature sources would be enabled by flight worthy wireless pressure sensors. This would provide wind tunnel test engineers and aircraft designer extremely valuable information about unsteady aerodynamics related to rotorcraft or other aerospace vehicles.

REFERENCES:
1) M. Yu and B. Balachandran, "Pressure sensor diaphragm under initial tension: linear analysis," Experimental Mechanics, Vol. 45 (2): 123-129, 2005.

KEYWORDS: wireless, micro-sensor, pressure transducer

A06-012 TITLE: Wake-Capturing Methods for General and Heavy-Lift Rotorcraft Flow Analysis

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Rotary-wing wake computation is a long-term difficulty – one that will be especially great with heavy-lift rotorcraft. The problem prevents rotorcraft CFD (Computational Fluid Dynamics) from realizing its full potential; i.e. the cost of wake computations has often removed it from the greater engineering process. Wake analysis is critical to rotorcraft engineering as it is central to predicting performance, acoustics, design, control issues etc. But current CFD methods require the largest/densest possible grids to compute wakes, and none of these has yet been adequate (especially for engineering use). Current dependence on grid density is inconsistent with the need to compute a "weak" solution that models an essentially discontinuous and inviscid wake structure - a problem that is similar to the classical concept of "shock-capturing" in compressible flows. And, like the latter, a proper weak solution should "capture" wake features within a very few grid cells. Shock-capturing works because the natural gasdynamic compression process easily overwhelms numerical diffusion at shocks. The physical basis of the convection difficulty is the lack of a natural compression mechanism. Attainment of such an essentially discontinuous solution can be attained by inclusion of a numerical compression - a process here referred to as "wake capturing". The objective of this solicitation is to develop a best method of "wake capturing" - one that eliminates the unbounded diffusion of wakes and describes them as having thicknesses of the order of the grid spacing - and to implement and demonstrate effectiveness on important rotorcraft wake problems using standard rotorcraft codes.

DESCRIPTION: In the context of present codes (in which a large user community is heavily invested and which will be required for heavy lift analysis), practical wake capturing requires development of computational measures to counteract numerical diffusion at discontinuities. As with shock-capturing, wake-capturing can be accomplished in many ways. This solicitation seeks a best approach, including rigorous explanation, demonstrations, method comparisons and effective implementation. Qualities sought in a best method include: (1) simplicity and compatibility with current rotorcraft codes, (2) intrinsic compatibility with the 3-D, compressible and incompressible, flow physics, (3) one which models, in the space of a few grid intervals, an ideal wake having no characteristic thickness (other than grid interval), (4) which results in a non-diffusing wake (i.e. whose thickness, for a given grid, does not grow with time), (5) which performs this capturing with no residual numerical (non-physical) effects on the solution (outside of the thin wake sheet interior). These features will be demonstrated on flows that typify the classic wake problems of rotorcraft in all flight conditions and will be implemented in codes in common use by the Army as well as the greater rotorcraft community. Features to be valued in a proposal will include clarity, demonstrated solution potential, potential for a broader understanding of rotor wake computation, and application in a code that has demonstrated itself in the rotorcraft user community.

PHASE I: Devise a theory of wake capturing, explaining it on both the heuristic and rigorous levels, as necessary for clarity, demonstrating conceptual commonalities (and differences) with the classic and related body of approaches to linear-advection/contact-discontinuity problems (including those in mainstream rotor codes) and full justifications for the particular approaches chosen. Provide a first implementation of this wake capturing in a suitable and well-recognized rotorcraft code. Illustrate the ability to compute the wake of isolated or multiple rotors operating from hover to a moderate advance ratio, showing the presence of known wake phenomena, all the while maintaining a thin wake region that demonstrably does not diffuse. In phase I, such demonstration computations will most strongly emphasize grid-size reduction and absolute wake preservation. Other types of wake flow solutions, illustrating the potential to compute complex wake interactions, could also be included. The point of such an array of computations will be to demonstrate an effectiveness of the capturing and a resulting grid size reduction, efficiency and simplicity of computation - thus demonstrating suitability for engineering code development in a Phase II.

PHASE II: Convert the Phase I demonstration capability into specific engineering analyses tools (having engineering analysis accuracy and a transparent setup and operation). That is, to establish a number of standard computation setups modeling a range of important engineering situations. The first of these is the analysis of a single rotor, including the ability to compute hover performance and some variants thereof (i.e. ground and wind effects). This includes enabling and demonstrating a local blade solution capability – thus demonstrating the capability to compute detailed high-lift and separation flows, having alleviated the burden of the wake computation (as required for future high disk-loading rotor analyses). Other computation modes supportive of heavy helicopter development will be sought, including analysis of various types of multiple rotors (tandem, counter-rotating, quad tilt-rotor, etc.)

PHASE III: Reduction of the burden of wake computation is basic to all rotorcraft analysis and needed for a wide range of military and commercial applications. Resulting performance prediction improvement is important for military and civil rotorcraft development and upgrades. Faster flow-field prediction will be strongly supportive of military operations, training and simulation; it will allow prediction of handling characteristics and provide the necessary basis for realistic visual simulations. Wake capturing will be a valuable capability for future commercial CFD software (which is often used by the military).

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1) Strawn, R. and Djomehri, M. J., “Computational Modeling of Hovering Rotor and Wake Aerodynamics,” Journal of Aircraft, Vol. 39, No. 5, Sept./Oct., 2002, pp.786-793.
2) von Neumann, J., and Richtmyer, R. D, "A method for the numerical calculation of hydrodynamic shocks", J. Appl. Phys., 21, 232-247, (1950).
3) Lax, P. D., and Wendroff, B., “Systems of Conservation Laws,” Comm. Pure Appl. Math. 13, p217, 1960.
4) Harten, A., “The Artificial Compression Method for Computation of Shocks and Contact Discontinuities III, Self-Adjusting Hybrid Schemes”, Mathematics of Computation, Vol. 32, No. 142, April 1978.
5) Colella, P, and Woodward, P. R., “The Piecewise Parabolic Method for Gasdynamical Simulations,” J. Comp. Phys., 54, pp.174-201.
6) Wenren, Y., Steinhoff, J. and Caradonna, F., “Application of Vorticity Confinement to Rotorcraft Flows”, 31st European Rotorcraft Forum, 12-16 September, 2005, Florence, Italy.

KEYWORDS: rotors, wakes, computational fluid dynamics (CFD), aerodynamic analysis, design

A06-013 TITLE: Enhanced Strength & Durability in Zinc Sulfide

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The goal of this topic is to develop methods or techniques that will provide a stronger and more durable Zinc Sulfide (ZnS) infrared window.

DESCRIPTION: Zinc Sulfide (ZnS) is one of a very few materials available for long wave infrared applications. If the application also requires visible or near infrared transmission, ZnS is almost the only candidate material available. While ZnS has excellent transmission properties throughout the visible and infrared regions, durability and strength have always been issues. Several variants of ZnS are available depending on the transmission requirements in the near infrared region. The most common form of ZnS, if near infrared transmission is required, is multispectral ZnS although other variants such as elemental ZnS have been demonstrated. None of the forms of ZnS have very high strength or durability. Recently, improved strength has been demonstrated in aluminum oxynitride (ALON) through careful post processing of the material such as with high quality surface finishing. The purpose of this topic is to develop similar processes which could be applied to ZnS to provide improved durability and strength.

PHASE I: Evaluate the feasibility of improving the strength of ZnS through post processing of the material. The effort should include a statistically valid sampling of the strength in currently available variants including, but not limited to, standard ZnS, multispectral ZnS, and elemental ZnS processed with conventional finishing techniques. The strength of 6 samples each (approximately 19 millimeters in diameter) of the post processed variants of ZnS must also be measured near the conclusion of Phase I. All strength testing should be conducted using the biaxial flexure test. Transmission data should also be provided.

PHASE II: Demonstrate a minimum 2x improvement in strength over conventional ZnS through the processes developed in Phase I. Success will be demonstrated by comparing biaxial flexure strength on small (25 milllimeter diameter) coupons. Sufficient coupons should be tested to establish a Weibull modulus (approximately 25-30 coupons). Transmission data should also be provided. Four 3” diameter domes processed with the techniques developed in this topic shall be delivered for possible thermal shock testing. The particular ZnS variant to be used for the domes will be determined during the course of the topic.

PHASE III:
High strength ZnS windows are required for dual band seeker applications requiring transmission at long wave infrared and laser designator wavelengths.

REFERENCES:
1) Harris, Dan, "Material for Infrared Windows and Domes", ISBN 0-8194-3482-5, SPIE Press, 1999.
2) Warner, Charles, et al, “Characterization of ALON Optical Ceramic, Window & Dome Technologies and Materials IX, Proceedings of the SPIE, Orlando, FL March 2005”.

KEYWORDS: optical ceramics, infrared windows, long wave infrared, zinc sulfide, manufacturing process, process improvement

A06-014 TITLE: Low Elevation Nulling of Global Positioning System (GPS) Jammers for Ground-Based Platforms

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop a cost-effective antenna electronics unit capable of nulling multiple low elevation GPS jammers for ground based platforms.

DESCRIPTION: Numerous Army systems today depend upon GPS for position and timing information. For many ground based launcher platforms, GPS is essential for proper initialization of missiles/rockets. With the Army’s dependence on GPS growing, the enemy’s attempt to utilize jamming to deny GPS acquisition/tracking also grows.

GPS jammers were used in the battlefield during Operation Iraqi Freedom and should be expected to be encountered during future conflicts. However, most Army launcher platforms do not utilize any type of GPS anti-jam (AJ) technology. There are several reasons as to why GPS AJ is not integrated on ground based platforms. Cost is a driving factor. AJ systems are still considered expensive and are typically integrated with high end weapons or aircraft. Air based weapons and aircraft require AJ technology that is dynamic from the standpoint of creating nulls in the direction of the jammer while minimizing the impact to satellite visibility. For air based platforms, line-of-sight (LOS) to the jammer is constantly changing, thus creating a dynamic environment for the AJ system to adapt to ground based jammers. Assuming air superiority (most likely before ground forces enter the battlefield), the optimum approach for ground based platforms is an AJ technology that provides a null against any low elevation jammer. In this case, an active 360 degree null could be formed to mitigate the effects of all ground based jammers independent of angle of arrival. A simplified antenna electronics unit could be developed which would allow a cost effective solution for all ground based platforms. The antenna electronics unit will be able to detect the presence of jamming and be capable of altering the antenna gain pattern to effectively attenuate all interference signals at the elevation at which the interference is detected. Based on production quantities (> 500 units), objective costs will be less than $1000 per unit. The size objective for the unit will be less than 27 cubic inches.

PHASE I: Define and determine the technical feasibility of design approaches. Identify the optimum solution based on size, cost, and schedule. Establish performance goals utilizing data from modeling/simulation. A final report detailing all Phase I development activities shall be generated.

PHASE II: Utilizing results from Phase I, fabricate a prototype system and demonstrate in a realistic jamming environment. Conduct environmental testing to ensure operation in predicted environments. Delivery of prototype system will include antenna, antenna electronics unit, and associated hardware. A final report detailing all Phase II development activities shall be generated.

PHASE III: A wide range of both military and civilian GPS users could benefit from this system. Jamming is not always intentional and is often encountered by civilian users in the telecommunications and airline industries. Users in these industries could utilize the system to maintain essential GPS timing information.

REFERENCES:

1) Parkinson, Bradford W., Spilker Jr., James J., Global Positioning System: Theory and Applications Volume II, American Institute of Aeronautics and Astronautics, Inc., Washington DC, 1996.
2) Kaplan, Elliott D., Understanding GPS Principles and Applications, Artech House Publishers, Norwood, MA, 1996.
3) Rounds, Steve, " Part I: Receiver Enhancements: Jamming Protection of GPS Receivers", GPS World, pp. 54-59, January 2004. http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=81907
4) Rounds, Steve, " Part II: Antenna Enhancements: Jamming Protection of GPS Receivers", GPS World, pp. 38-45, February 2004. http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=85268
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9) Website http://www.defense-update.com/products/g/gps-aj.htm, “GPS Anti-Jam Protection Techniques”.
10) Website http://www.military-aerospace-technology.com/article.cfm?DocID=369, “GPS Anti-Jamming Technology”.

KEYWORDS: masking, nulling, suppressing, low elevation, horizon, Global Positioning System (GPS), GPS jammer, GPS interference

A06-015 TITLE: <u>Low Cost Finishing of Optical Ceramics</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The goal of this topic is to develop methods or techniques that will reduce the optical fabrication costs of optical ceramic domes by a factor of two.

DESCRIPTION: Optical ceramics such as aluminum oxynitride (ALON) and spinel are durable materials with excellent transmission properties from the visible to the midwave infrared. These materials have applications as sensor windows and domes as well as transparent armor. The drawback to these materials, as for most durable optical materials, is the cost of optical finishing. The processes and tooling used to create an optical surface on a ceramic dome, for example, can easily be 1/3 the cost of the finished dome. Significant reductions in the cost of optical finishing these domes could save the Department of Defense millions of dollars in procurement costs.

PHASE I: Evaluate the feasibility of reducing the cost of optical fabrication for ceramic domes by a factor of two. The evaluation should include demonstrating the fabrication technique on both flat coupons and curved surfaces such as domelets. The feasibility study should also include an analysis supporting the projection of a 50% reduction in optical fabrication costs for a full size dome. Biaxial flexure strength and transmission measurements should be performed on the polished flats to demonstrate that the new techniques do not compromise strength or optical performance. Procurement of the ceramic blanks should be included as part of the cost proposal.

PHASE II: Demonstrate a minimum 50% reduction in optical fabrication costs for a full size dome. The cost of all dome blanks needed for the demonstration should be included in the cost proposal.

PHASE III: Optical ceramics are used for a variety of missile domes, seeker windows, and aircraft. A factor of 2 reduction in the optical fabrication costs would result in significant savings for the Department of Defense.

REFERENCES:
1) Harris, Dan, "Material for Infrared Windows and Domes," ISBN 0-8194-3482-5, SPIE Press, 1999.

KEYWORDS: optical ceramics, infrared domes, optical fabrication, manufacturing cost

A06-016 TITLE: Missile Flight Weather Encounter Software for System Requirements Development

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this topic is to develop a validated analysis software package that can be used as a system requirement estimation tool to aid the aviation/missile development community in establishing real-world probabilities of encounter various weather related events. This tool will be able to predict the probability of specific rain events, perform multiple simulations to estimate the worst-case missile launch point or air/rotorcraft flight path for a given path/trajectory, and be able to couple to other tools so that particle demise effects can also be estimated for the higher speed encounters. Of interest are the classification, probability, and categorization of rain, snow, ice, sand, and dust as a function of geographical latitude and altitude. This code will provide the aviation (helicopter and aircraft) and missile system integrators with an accurate and up to date tool needed to properly link weather event ground testing to real-world flight environments. This tool will also be valuable to aviation parts manufactures such as window and rotorblade designers to estimate a more realistic flight environment for their products.

In recent years, we have pushed the ground test facilities that were developed in the 1960's and 1970's to near their limits. There currently exist significant constraints on these facilities to "match" flight test weather event levels. These limitations make it all the more important when the system integrator must extrapolate the ground test results nearly an order of magnitude to match flight test data. Because of this, understanding the real-world weather environment becomes essential if the system component is not to be significantly over-designed. Coupled to this is the speed and performance of missiles, high-speed aircraft, and helicopter rotor systems currently in development, we are pushing the performance envelope beyond what the standard materials commonly used in older systems can deliver. These legacy materials are now no longer acceptable and new materials are currently under development. Due to the lack of experience utilizing these newer materials however, it is essential that the proper flight environment be tested so that realistic flight performance can be predicted.

This task promises to provide a significant opportunity for current and future aviation and missile systems to greatly decrease component costs due to over-designing, while simultaneously assisting in verifying the performance, versatility, and durability of materials in more realistic environments. Over-testing in unrealistic weather scenarios, due to lack of understanding of the real-world events drive higher component costs for radomes, shrouds, fairings, window anti-reflection coatings and seals, helicopter blades and even booster cases. As the "all weather" Army unfolds, research tools such as this are crucial for proper in-theater all-weather capabilities for all flight systems.

DESCRIPTION: The definition and probability of weather events at various latitudes will form primary core of the program. Such information is commonly calculated and measured in the meteorological community. Radar data has established both the particle size and size distribution, as functions of ground track, altitude, and precipitation type and shape. The code will be able to utilize various weather definitions in predicting the incident mass flux and integrated mass flux for a generic flight system given the trajectory or flight plan as input. The code will then be able to perform numerous simulations to determine the worse case launch point or flight path for a given weather event. The code will also have output file capabilities such that the Army can quickly utilize this data in various other types of system analysis software currently in use.

The code shall be able to provide various performance metrics that will enable the engineer to rapidly assess how the weather environment changes as a function of its various input parameters. The highest-level of the software architecture should be able to perform hundreds of hands-free trade studies in order to assess the most optimal path for the problem at hand. A user interface should incorporate a Graphical User Interface (GUI) for ease of use. The software needs to run on personal computers running Microsoft operating systems.

PHASE I: The focus of the Phase I effort is to develop a software hierarchy as to what methodologies, codes, or techniques will be used to deliver the weather assessment and optimization software. The elements that must be present in the software include:
• Trajectory/flight path simulation (altitude, velocity, angle of attack, pitch and yaw, as a function of time)
• A library of weather events (example: particle type, size, distribution, as a function of altitude and ground track, etc.)
• The probabilities associated with each event as a function of latitude or global position.
• A architecture to perform multiple runs and assess worst case launch points/flight paths with respect to given or random weather formations
• Simplified and flexible input and output capabilities to interface with other codes.
• Output plotting routines such that large amounts of data can be quickly assessed with statistical significance.

PHASE II: The Phase II effort will provide a completed and integrated weather encounter software package enabling more accurate definitions of the weather space enabling the end user to perform more accurate analyses and optimization of aviation components. The code shall be fully checked and benchmarked with the results presented. A full set of user documentation shall be provided which will enable end users to fully utilize the capabilities of the software. The checkout cases utilized in validating the software during the Phase I and Phase II efforts will be detailed.

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. The completed software package could be marketed as an enabling technology to predict realistic flight environments for suppliers of aviation parts to verify/validate their part's performance.   Products that would derive benefit from this technology include but are not limited to: helicopter blades, missile radomes, aircraft antennas, aircraft windows, seals, infrared windows, and anti-reflection and radar absorbing coatings. The resulting weather definitions as integrated into analysis software would provide significant benefit to commercial aviation systems. These benefits could be recognized in subsonic flight environments to support erosion and impact damage assessments on coatings, optical windows, aircraft wing/blade leading edges, as well cockpit canopies/windows. Additionally, it is anticipated that much of the weather definition capability will be directly leveraged through collaboration with commercial weather analysis organizations such as the National Oceanic and Atmospheric Administration (NOAA). The prediction of weather environments can substantially support commercial air traffic through flight waypoint definitions to minimize risk of hazardous weather encounter.

REFERENCES:
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2) Short Course in Cloud Physics, Third Edition (International Series in Natural Philosophy) by M. K. Yau, R. R. Rogers, publisher: Butterworth-Heinemann; 3 edition (January 1, 1989), ISBN: 0750632151.
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KEYWORDS: Weather definition, Meteorology, Optimization Software, Monte Carlo Simulations, Particle Demise, Rain/Snow/Ice encounters, Trajectory Shaping, Graphical User Interface

A06-017   TITLE: Super-Nanocomposite Components for Advanced Interceptors

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Exo-Atmospheric Product Office, MDA, Joint Program Office

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 development of nanocomposites that can greatly improve the strength, ablation resistance, thermal performance, and radiation hardening of advanced interceptor structures (Exoatmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor) which is cost effective, easily serviceable, safe, reliable, and efficient.

DESCRIPTION: New Super-Nanocomposites hold the promise of a unique combination of properties not found in single phase materials. They are considered super because of the potential to achieve ultra high strengths, high stiffness, low densities, corrosion resistance, and radiation hardening by incorporating such fillers as carbon nanotubes, the strongest and stiffest known material. These nanocomposites could be utilized in advanced interceptor structures (Exoatmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor) including nosecones, mid-body structures, missile skins, motor casings, and seeker optics and mirrors. In such applications, these materials could offer improved structural strength, hypersonic ablation resistance, and thermal performance at low costs. In addition, optimum compositions might also provide for radiation hardening of missile components. This research will involve the development of advanced nanocomposite materials for missile components and structures.

PHASE I: Explore the concept and develop a nanocomposite based missile component. Produce test coupons of the material and measure relevant properties. Provide a feasibility study that addresses cost, service methods, safety, reliability and efficiency. Perform a manufacturability analysis and cost benefit analysis of deployment showing that the structure can be produced in reasonable quantities and at reasonable cost/yields, based on quantifiable benefits, by employing techniques suitable for scale up. Provide a report on scalability, performance characteristics, anticipated yield, and volume costs.

PHASE II: Based on the results and findings of Phase I, implement the technology, fabricate, and test a prototype on a representative missile structure with carbon nanotube based composites. Demonstrate the system's viability and superiority under a wide variety of conditions typical of both normal and extreme operating conditions. Using available validated structural analysis software to analyze this new class of nanocomposites. Demonstrate scalable manufacturing technology during production of the articles.

PHASE III: Verification of overall approach. Provide a final design for an innovative nanocomposite structure that will provide nuclear survivability. The proposed technology under this effort would advance the state-of-the-art in missile structural performance (Exoatmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor), safety, life extension, preventative and other maintenance, enhanced turbine blade performance for wind energy production in low speed/turbulent conditions, earthquake resistant buildings, deformable hydrofoils for high performance submersibles, and in a spectrum of other areas, for both the government and private sectors. Demonstrate commercial scalability of the manufacturing process and the implementation of the software-based design tools for the commercial development and deployment of advanced structures. Commercialize the technology for both military and civilian applications.

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KEYWORDS: Carbon nanotubes, nanotechnology, nanocomposites, interceptor, radiation hardening, manufacturing engineering

A06-018 TITLE: Computational Fluid Dynamics Modeling for Electrically Conducting Flows

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop the methodology for the analytical prediction of multi-phase, chemically reacting, flowfields as electrically conducting media.

DESCRIPTION: There are a number of new applications for flowfield modeling wherein the participation of the flowfield as an electrically conducting media is of paramount importance. These include drag reduction for high speed missiles, control of high speed missiles, control of cavity aero-acoustics, the use of micro-electro-mechanical systems (MEMS) devices to control flows, and controlled energy addition to propulsive flows. Phenomenologically, these applications differ significantly from more classic but related problem areas such as microwave propagation through rocket exhaust plume flowfields in that the fluid flowfield will be strongly coupled to the electrical/magnetic fields rather than acting as a passive conducting media. Modeling for all of these important applications requires the solution of the Navier-Stokes fluid mechanics equations coupled to the Maxwell equations for electrical propagation.

The key technical problem which arises in the formulation of numerical solution schemes for these equation sets is in the definition of the solution grid space. Typically, solution of the governing fluid dynamics equations for chemically reacting, multi-phase flows requires a geometrically fine computational grid, either structured or unstructured, that is concentrated in areas of high flow gradients (shock waves, boundary layers, shear layers, and separated flow regions) and areas of the flowfield where strong chemical reactions and/or phase change are occurring. By comparison computational electromagnetics solutions schemes use much coarser geometric grids or even solid geometric models for the computational space definition though regions of strong electrical and magnetic gradients require still require grid refinement. Hence, there is a mismatch in grid density requirements for the two equation sets and, additionally, the various regions of grid concentration do not necessarily overlap.

One possible solution to this grid definition dilemma is to use one geometric grid and concentrate grid points in regions of large gradients, either fluid dynamic or electromagnetic. Another solution is to have two separate grids tuned to each phenomena. This, however, raises issues such as any interaction between the force field due to the electrical field and the flow field and decomposition of the geometric regions with communication issues between the grids. Implications here include strong vs. weak coupling of the phenomena. All of these considerations must be evaluated in order to approach first, a grid strategy and second, a solution strategy for the set of non-linear, coupled partial differential equations. Clearly a new and innovative modeling architecture is required to overcome the existing grid definition limitations. To be both practical yet adequate, the formulation of such an innovative and improved approach must give special consideration to the following:
1. The modeling architecture must incorporate the existing and extensive time -accurate, finite-volume, Reynolds-averaged, Navier-Stokes flowfield solution methodology including models for two-phase, gas-particle flows, and finite-rate chemistry.
2. The modeling architecture must incorporate the existing state-of-the-art solution techniques from computational electromagnetics.
3. Intelligent processor control for domain decomposition among multiprocessors.
4. Dynamic and adaptive grid development to achieve adequate grid resolution both spatially and temporally to capture the flowfield features possibly using hybrid structured/unstructured grids as appropriate.
5. Fluid dynamic and electrical propagation time scales may be incompatible with consequent stiff matrices and small solution time steps.
6. Innovative solution techniques such that transient physical processes can be modeled while achieving solutions in a reasonable time period.

PHASE I: Phase I proposals must demonstrate: (1) a thorough understanding of the Topic area, (2) technical comprehension of key fluid dynamic and electromagnetic problem areas, (3) previous computational fluid dynamics experience in modeling transient, three-phase, nonequilibrium gas-particle, chemically reacting flows with a computational fluid dynamics (CFD) code possessing those capabilities, and (4) previous computational electromagnetic modeling experience.

Technical approaches will be formulated in Phase I to address the key problem areas. If proven feasible, at least one innovative architecture will be coded and exercised during Phase I to assess the potential for Phase II success.

PHASE II: The additional model improvements formulated in Phase I will be finalized, documented, and coded to form an initial integrated computational fluid dynamics/electromagnetics flow/propagation solver.

PHASE III: This technology has direct military application to include drag reduction for high speed missiles, control of high speed missiles, control of cavity aero-acoustics, and controlled energy addition to propulsive flows. For commercial applications, this technology is directly applicable to space vehicle power generation and especially for long missions where magneto-hydrodynamics can be employed.

REFERENCES:
1) Anderson, J. D., Computational Fluid Dynamics, (ISBN: 0070016852) McGraw-Hill, 1995.
2) Peterson, A. F., Ray, S. L., and Mittra, R., Computational Methods for Electromagnetics, (ISBN: 0780311221) IEEE Press, 1997.
3. http://www.darpa.mil/MTO/MEMS/

KEYWORDS: e-beam power, electric fields, magnetic fields, computational fluid dynamics, computational electomagnetics, drag reduction, aircraft, missiles

A06-019 TITLE: Dissolvable Jet Vanes for Rocket Propelled Missiles

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: This program will develop low cost, weight, and drag materials, structures, and processing technology for tactical missiles that use jet vanes to provide aerodynamic control until control surfaces are deployed.

DESCRIPTION: Land or ship-borne defensive missiles are generally launched from a canister in a nearly vertical orientation. Missiles generally have steering control systems which include external aerodynamic control surfaces for guiding the missile. Before its aerodynamic control surfaces or fins are able to affect any significant maneuvers, the missile must achieve a certain minimum velocity, referred to herein as the aerodynamic control velocity, to cause enough air to flow over the aerodynamic control surfaces and provide aerodynamic control. For a ballistic launch trajectory, the missile reaches an altitude of thousands of feet before the aerodynamic control surfaces can cause the missile to pitch over and begin seeking the target. As a result, a ballistic launch trajectory is inefficient, time consuming, and limits the missile sensor line-of-sight capabilities for optimum target detection and tracking.

Existing systems generally also can be classified as either non-detachable or ejectable, the latter often incorporating redundant control electronics. Non-detachable systems limit mission range and performance with rocket thrust degradation throughout the missile trajectory. A non-jettisoned Thrust-Vector Control (TVC) system will degrade rocket motor performance (specific impulse) up to 16% via plume induced drag.

To overcome the deficiencies of prior systems, systems have been developed that place a mechanism in the exhaust plume of the rocket engine for control purposes, providing control immediately upon launch. Generally, the purpose is to pitch the missile over (rotate the missile about an axis transverse to the longitudinal axis and previous direction of flight during launch) and to avoid rolling. Rolling generally interferes with operation of the missile guidance system and is a problem that is minimized at low velocities by placing the control surfaces within the exhaust plume.

PHASE I: Develop jet vane concepts for multiple material candidates based on representative rocket plume environments. Analytically evaluate candidate materials for jet vanes that have the potential to dissolve in a controlled manner in the rocket exhaust. Select the best material(s), coatings, and processing approach that minimizes cost. Define a path for development and demonstration of the technology in Phase II and Phase III programs.

PHASE II: Use a combined analytical and experimental program to develop and demonstrate the viability for using dissolvable jet vanes for a tactical missile application. The concept will be developed in detail including the vane support structure. Representative jet vanes will be fabricated and testing will be conducted to verify the approach for dissolving the material in a representative rocket plume environment. Tests will be conducted to verify the repeatability of the process for dissolving the jet vanes. Cost models will be developed and used to project manufacturing costs for approximately 30,000 jet vane sets.

PHASE III: The technology developed in this program will have application to both military and commercial applications that require a shape change or morphing of an aerodynamic shape due to either being in a rocket plume or, if subjected to severe aerothermal dynamic heating. In one extreme, the heated surface completely dissolves. In the other, a portion of the surface dissolves leaving a new surface better suited for a changing environment.

Another application is to address restrained firing. The idea is to use an ablatable material as the hot plate, which burns through if the heat is applied for more than 2 seconds. The plume would also quickly burn through the aft cover and into a plenum that would be large enough to contain the propellant.

Potential other applications of the technology would be for thrust vector controls for commercial launch vehicles, morphing structures in hypersonic vehicles (shape changes as an outer layer of material ablates), and to control hot propellant gases on ships in a restrained firing condition (container material ablates and allows hot gases to pass into a holding tank).

Other than ablatable jet vanes for Thrust Vector Control, other applications would be hypersonic missile fins that change by way of ablation due to changing mission parameters such as flight profile, altitude, velocity, or responsiveness.

REFERENCES:
1) AIAA 90-1860 Inverse Heat Transfer Studies and the Effects of Propellant Aluminum on TVC Jet Vane Heating and Erosion, A. Danielson, Naval Weapons Center, China Lake, CA, 26th JPC July 16-18, 1990, Orlando, FL.
2) Testing and Empirical Analysis Methods for Jet Vane Improvement, A. O. Danielson, TTCP, Subgroup W, Technical Panel W-4, Energetic Materials and Propulsion Technology, Technology Workshop, 18-19 April 1996, Adelaide Australia.

KEYWORDS: Jet vanes, dissolvable, low cost

A06-020 TITLE: Transient, Rocket Exhaust Plume Modeling for Static Test Analyses

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop innovative models for the basic physical and thermochemical processes describing transient, two-phase, gas-particle, chemically reacting rocket exhaust plume flowfields within static test environments which can replace the existing models which currently limit plume signature and interference modeling.

DESCRIPTION: Static testing continues as the most prevalent, economical, and practical method to obtain plume signature and interference data and, through validated models, for extension to the dynamic flight environment. Static testing offers significant advantages for these measurements since position is fixed, data is more easily collected, instrumentation can be positioned without regard to motion, risk is easily managed, and costs are low by comparison to all other alternatives. Simulation and analysis of the detailed physical processes associated with ultraviolet/visible/infrared radiation and electromagnetic wave propagation under static test conditions, not unlike the flight environment where applicable, requires field descriptions of the transient two-phase, gas-particle, chemically reacting rocket exhaust plume flowfield over the entire motor burn from ignition through and beyond motor shut-down while accounting for the factors peculiar to the static environment. The available rocket exhaust plume modeling methodology for static test conditions is essentially limited to those plume flowfield models developed specifically for in-flight conditions and largely because validated flight models are the intended end user product. However, these existing computational fluid dynamic (CFD) plume flowfield models for in-flight missile rocket exhaust plumes, even when run at the limiting case of zero flight velocity, do not well represent static test conditions; and, hence, severely limit the results from companion models for plume signatures and interference effects and the use of those results for flowfield model validation.

The static test regime is unique in that environmental factors not encountered in flight can have a significant impact on measured rocket exhaust plume signatures and interference effects. Static motor firings, for example, are all too often conducted in test cells with test stand hardware, containment walls, and floor in close proximity to the exhaust plume nearfield and all manner of trees, hills, and dirt embankments within the plume farfield. Here dirt entrainment and reflected/traveling shock waves come into play along with flowfield obstruction. The analyst must gauge the impact of these factors on the measured plume signature and interference results with no means save modeling and deficient modeling at that.

Even with elevated static test stands specifically designed to limit physical interference effects, the influence of wind, humidity, and buoyancy must be considered by the flowfield models along with the deposition of plume effluent - both particulate and gas - as a static motor burn progresses. Indeed, the displacement of the surrounding air mass by the exhaust plume remains both unique and key to static test modeling. Furthermore, treatment of a true quiescent flowfield initial condition remains as a problem with existing plume CFD flow solvers tailored for flight simulations.

Clearly a new and innovative modeling architecture is required to overcome the existing limitations for static test conditions. To be both practical yet adequate, the formulation of such an innovative and improved approach must give special consideration to the following: 1. The modeling architecture must incorporate the existing and extensive time -accurate, finite-volume, Reynolds-averaged, Navier-Stokes flowfield solution methodology including models for two-phase,
gas-particle flows, and finite-rate chemistry.
2. Strongly coupled particulate interaction effects including turbulence dispersion and modulation.
3. Physical constraints including plume impingement and entrainment.
4. The correct temporal development of the plume flowfield including wind effects and buoyancy must be preserved for post-processing with selected plume interference and signature models. Modeling must account motor transients since those are suitably well known; however, it will not be necessary to fully model internal motor ballistics as rocket motor performance is usually known and can be coupled to an exhaust plume model through inflow conditions.
5. Intelligent processor control for domain decomposition among multiprocessors coupled with flowfield interrogation to identify the dominant physical processes at the local level and apply the most applicable solution methodology to each domain.
6. Dynamic and adaptive grid development to achieve adequate grid resolution both spatially and temporally to capture the flowfield features possibly using hybrid structured/unstructured grids as appropriate.
7. Fluid and chemistry time scales are incompatible with consequent stiff matrices and small solution time steps particularly over an extended plume flowfield.
8. Innovative solution techniques such that the required transient physical processes can be modeled while achieving solutions in a reasonable time period.

PHASE I: Phase I proposals must demonstrate: (1) a thorough understanding of the Topic area, (2) technical comprehension of key transient plume flowfield problem areas, and (3) previous computational fluid dynamics experience in modeling transient, two-phase, nonequilibrium gas-particle, chemically reacting flows with a CFD code possessing those capabilities. Technical approaches will be formulated in Phase I to address the problem area for later inclusion into computational fluid dynamic models utilized by the exhaust plume community. At least one innovative architecture will be coded and exercised during Phase I to assess the potential for Phase II success.

PHASE II: The additional model improvements formulated in Phase I will be finalized, documented, coded, and incorporated into an existing Government computational fluid dynamics code. The improved computational fluid dynamics model will be run blind for a series of static solid propellant rocket exhaust plume test cases for which detailed plume signature and interference data is available to demonstrate the advanced capabilities for analyzing and modeling transient, rocket exhaust plume flowfields within static test environments.

PHASE III: For military applications, this technology is directly applicable to all tactical and strategic missile development programs. For commercial applications, this technology is directly applicable to environmental analysis techniques for applications such as aerospace launch systems.

REFERENCES:

1) Simmons, F. S., Rocket Exhaust Plume Phenomenology, ISBN 1-884989-08-X, AIAA, 2000.
2) Dash, S. M., "Missile Flowfield Modeling Advances and Data Comparisons," AIAA Paper 2000-0940, 2000.
3) http://www.rttc.army.mil/resources/ta5.htm
4) http://www.nawcwpns.navy.mil/techtransfer/facility/plummeas.htm
5) http://www.ssc.nasa.gov/~sirs/photos/propulsion/low/87-242-23.jpg
6) http://www.edwards.af.mil/archive/2004/2004-archive-teststand_2a.html

KEYWORDS: exhaust plume, turbulence models,computational fluid dynamics,structured grids, two-phase, gas-particle flow, unstructured grids, finite-rate chemistry, numerical methods

A06-021 TITLE: Modeling and Simulation of Missile and Munition Power Sources

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Conceive and design credible and verifiable modeling and simulation tools, which could be implemented to streamline development of missile and munitions power sources. Establish means to characterize materials for structural and thermal behavior, perform parametric modeling for design optimization, and to verify performance, structural integrity, and reliability when subject to Army Tactical environments.

DESCRIPTION: Nearly every torpedo, mine, missile, or munition which is powered for electronics, for control actuation, for sensing, or fusing depends upon a primary (thermal) battery for its power source. These devices are intrinsically suited for long-term dormant storage, and can provide both high voltage and variable current/power on command for a limited duration. Thermal batteries exist as "one-shot" devices, composed of internal cells whose layered composition includes powdered anode/electrolyte/cathode materials, pressed into pellets and stacked in columns. The electrolyte remains ionically immobile until activated by an integral source of heat through melting. The cell components in the battery are assembled into a cannister with integral electrical header connectors, the former of which acts to both support the cell stack structurally and to create necessary hermetic seal. Activation of the system transforms the cell elements from particulate composite solids into semi-viscous conglomerates.

Great effort in terms of cost, performance, and schedule is expended whenever a new power source begins design and development for use in a military weapons system. In part, this is due to the fact that very limited capability exists among qualified battery vendors to perform design through Modeling and Simulation (M&S). Detailed thermo-chemistry modeling is necessary to balance performance with heat management; for it is the "heat balance" which controls the internal reaction rate of the active materials, and allows performance to be optimized for the broad operational temperature range (which may be from -50F up to +160F).

Of greater difficulty still, is the lack of ability to model the component structural behavior when subject to the wide range of tactical dynamic environments to which the component will need be qualified; to include transportation vibrations, operational launch shocks, and pyroshock events. This forces weapons system programs to pay for costly Developmental Verification Test (DVT) series, in which component testing is performed, in replicate, to nearly all of the required environments prior to entering into formal qualification. The process of design for performance in dynamic environments exists as one in which modifications are evolved by trial and error prototype testing, and the optimum design does not always readily surface.

Given the advanced state-of-the-art for computational and numerical fluid dynamics, heat transfer, and structural analysis, it is important that these tools be brought to bear in support of missile and munition power sources design and development. Simulation tools, with Graphical User Interfaces (GUI), need evolution and specialization for use within Government laboratories and the power sources industry to reduce design risk, to improve design optimization capability, and to relieve the cost and schedule burden imposed upon the Department of Defense (DoD) in weapons power sources development.

PHASE I: Conceive means by which component materials and structural elements in missile and munitions power sources can be characterized for thermo-chemistry, heat transfer, and structural constitutive behavior; with emphasis on phase transition. Conceive modeling techniques, in which the detailed element or lumped mass response of active materials, insulation materials, and metal containers can be treated analytically to accurately predict the system response in thermal and dynamic environments. Conceive and create a modular Modeling and Simulation tool/environment, in which basic design configurations could be graphically represented, and in which various design parameters could be modeled and traded for optimization. Evolve coupled thermal and structural solution approaches when subject to dynamic environment boundary conditions.

PHASE II: Perform basic characterization of battery components, active and insulation materials to determine their thermal and structural properties in the stored and active configuration for modeling. Define constitutive model forms for use in computer finite element codes.

Refine and optimize a modular modeling and simulation tool/environment, to perform modeling of power source basic design configurations parametrically treating cell stack geometry, insulation materials, cannister designs. Perform coupled structural and thermal modeling of a +28V equivalent power source, subject to selected dynamic environmental boundary conditions. Build and test prototype battery(s) for verification of model predictive capability. Employ coupled thermal and structural solution approaches to evaluate design during phase transition from dormant to active state.

PHASE III: Phase III military applications include power sources for all weapons systems which employ primary (thermal) power sources. To a lesser extent, similar power source development for deep space commercial applications will benefit. Moreover, modularity of the modeling tool allows expansion to applications as varied as commercial aircraft or automotive power sources or safety systems power sources.

REFERENCES:
1) "Thermal Batteries", Molecular Expressions; Introdcution, Florida State University, Website, http://micro.magnet.fsu.edu/electromag/electricity/batteries/thermal.html

KEYWORDS: Power Sources, Modeling and Simulation, Electricity and Magnetism

A06-022 TITLE: Software-Based Anti-Tamper Technique Research and Development

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop and implement new innovative software anti-tamper (AT) techniques that demonstrate the capability to delay, or make economically infeasible, the reverse engineering or compromise of U.S. developed software embedded in U.S. Army weapon systems.

DESCRIPTION: All U.S. Army Project Executive Offices (PEOs) and Project Managers (PMs) are now charged with executing Army and Department of Defense (DoD) AT policies in the design and implementation of their systems. Embedded software is at the core of modern weapon systems and is one of the most critical technologies to be protected. AT provides protection of U.S. technologies against exploitation via reverse engineering. Standard compiled code with no AT is easy to reverse engineer, so the goal of employed AT techniques will be to make that effort more difficult. In attacking software, reverse engineers have a wide array of tools available to them, including debuggers, decompilers, disassemblers, as well as static and dynamic analysis techniques. AT techniques are being developed to combat the loss of the U.S. technological advantage, but further advances are necessary to provide useful, effective and varied toolsets to U.S. Army PEOs and PMs. Current software AT techniques, such as code obfuscation, anti-static and dynamics analysis tools, and anti-debug tools are often only marginally effective. This effort will focus on developing innovative new software AT techniques and technologies that provide more protection from compromise than such current methods. In most cases, these real-time embedded systems utilize code developed in C++, and then operate on real-time operating systems like Wind River's VxWorks on embedded processors, such as the PowerPC, in a target weapon platform. Attention will be placed on integration into embedded platforms and their "real-time" processing requirements. The goal of software AT technologies/techniques developed is to provide a substantial layer of protection against reverse engineering, allowing for maximum delay in an adversary compromising the protected code. This capability will allow the U.S. time to advance its own technology or otherwise mitigate any losses of weapons technologies. As a result, the U.S. Army can continue to maintain a technological edge in support of its warfighters.

PHASE I: The contractor shall design and develop new and innovative software-based AT techniques/technologies to protect the total system software or critical portions thereof from compromise via reverse engineering. The contractor will also perform an analysis to estimate the degree of protection afforded by the AT techniques and provide an analytical rationale for the estimate.

PHASE II: Based on the Phase I effort, the contractor shall further develop and incorporate the software AT techniques into one or more prototype software modules written in C++ and estimate the effectiveness of the techniques employed and their applicability to real-time applications. A required Phase II deliverable shall be a copy of the anti-tampered software module(s), along with documented software AT technique code, to allow for Government assessment of the techniques in preventing compromise of critical software.

PHASE III: The contractor shall integrate selected AT techniques into embedded critical system software, for a military and/or civilian platform. This phase will demonstrate the product's utility against DCMA infringements, reverse engineering/exploitation, and/or industrial espionage, problems that impact the U.S. Army and its mission. When complete, an analysis will be conducted to evaluate the ability of the technologies/techniques to protect against tampering in a real-world situation.

REFERENCES:
1) Wills, L., Newcomb, P., Eds. Reverse Engineering, Kluwer Academic Publishers, 1996.
2) Ingle, K. A. Reverse Engineering, McGraw-Hill Professional, 1994.
3) Cerven, P. Crackproof Your Software: Protect Your Software Against Crackers, No Starch Press, 2002.
4) Erickson, J. Hacking: The Art of Exploitation, No Starch Press, 2003.
5) Arxan Technologies White Paper: Anti-Tamper Software Protection, Arxan Defense Systems, 2003.
6) Koziol, J., Litchfield, D., etc. The Shellcoder's Handbook : Discovering and Exploiting Security Holes, John Wiley & Sons, 2004.
7) Kaspersky, K., Tarkova, N., Laing, J. Hacker Disassembling Uncovered, A-List Publishing, 2003.
8) Hoglund, G., Gary McGraw. Exploiting Software: How to Break Code, Addison-Wesley, 2004.
9) Aladdin Software Protection Whitepaper- The Need, the Solutions, and the Rewards, Aladdin Knowledge Systems, 2003.

KEYWORDS: Anti-Tamper, Embedded Software, Reverse Engineering, Hacking, Obfuscation, Exploitation, Disassembly, Decompile, Static Analysis, Dynamic Analysis, Real-time

A06-023 TITLE: Alternate Green Body Dome Fabrication Techniques

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop a low cost process for the fabrication of green bodies domes.

DESCRIPTION: The current methods of fabricating spinel and aluminum oxynitirde (ALON) dome green bodies consist of filling a mold with powder and using cold isostatic pressing (CIP) to make it into a semi-solid. This method is time consuming due to the handling of the powder an placing it into the mold and expensive due to the handling time and CIP equipment and process time. This effort will evaluate other methods of making dome green bodies out of spinel and ALON to determine and develop a more cost effective fabrication technique. The technique to be developed must be capable of making a full hemispherical dome of at least 7" in diameter that will exhibit, at a minimum, 84% transmission at 4.5 microns, 80% transmission at 0.7 microns, have a thickness of 0.180 inches and a refractive index homogeneity better than 100 ppm over a 160 degree aperture.

PHASE I: Develop and demonstrate low cost approach to make a green body 4" domelet (4" dia. sample with a 7" radius) that will exhibit, at a minimum, 84% transmission at 4.5 microns, 80% transmission at 0.7 microns, have a thickness of 0.180 inches. The developed technique will then be used to demonstrate the fabrication of a 7" green body dome.

PHASE II: Refine the developed process so that it is consistently capable of making domes that meet the above requirements. Demonstrate the process, through the production of at least 10 samples that will be provided to the Government for evaluation. Target production rate is 10,000 domes per year.

PHASE III: There is an ever increasing need for low cost domes that have the characteristic of the spinel and ALON domes. The development of a low cost green body dome fabrication technique for missile systems required to withstand harsh environments assist in reducing system costs.

REFERENCES:
1) Harris, Dan, "Material for Infrared Windows and Domes," ISBN 0-8194-3482-5, SPIE Press, 1999.
2) Kirsch, James C, et al, Tri-Mode Seeker Dome Considerations, Window & Dome Technologies and Materials IX, Proceedings of the SPIE, Orlando, FL March 2005. Preprints will be available upon request.

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

A06-024 TITLE: Green Body Machining of 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 goal of this topic is to develop methods to machine dome green bodies to the dimensions that will eliminate most of the grinding and polishing requirements.

DESCRIPTION: Current methods for the production of spinel and aluminum oxynitride (ALON) domes require extensive grinding and polishing processes which are time consuming and costly. The development of the capability to machine the green dome to a specific shape would greatly reduce the time and expense of current grinding and polishing processes. It may also allow for the reuse of the material removed during the matching process. This effort will determine the feasibility of machining hemispherical dome of seven inches or greater. It will also evaluate the reuse of the machined material for additional cost reduction. It is anticipated that the machining process would have to be capable of machining a 160 degree hemispheric dome to a thickness of 0.0450” with a smooth surface finish (500 micro-inch or better), inner and outer radii within 0.02 inches of nominal surface profile, inner and outer radii within 0.02 inches of true positional tolerance of each other and an overall sigital height tolerance of 0.05 inches. The resultant green dome will be able to under go follow-on processing of cold isostatic pressing (CIP), sintering, and hot isostatic pressing (HIP) without cracking or warping.

PHASE I: Evaluate the feasibility of machining green body spinel and ALON domes with a dimension of seven inches or greater. Variables to be evaluated will include but will not be limited to powder shape and size, binders, green body density, machining feed and speeds, tooling and fixtures.

PHASE II: Demonstrate that a spinel or ALON green body 7”, 160 deg. hemispherical dome can be machined to the repeatable tolerances. The resultant green dome, either in the original green state or after cold isostatic pressing (CIP) state will be capable of under going appropriate follow-on processing such as CIP if not already done, sintering, and hot isostatic pressing (HIP). The repeatability of the process shall be demonstrated by fabricating 10 dome blanks to the above requirement using the developed process. The 10 dome blanks should not show any cracking or warping.

PHASE III: Based on the improved properties of spinel and ALON domes and the maturation of the manufacturing processes, there is an increasing demand for their incorporation in to missile seeker systems. Cost reduction effort are need improved affordability.

REFERENCES:
1) Harris, Dan, "Material for Infrared Windows and Domes," ISBN 0-8194-3482-5, SPIE Press, 1999.
2) Kirsch, James C, et al, Tri-Mode Seeker Dome Considerations, Window & Dome Technologies and Materials IX, Proceedings of the SPIE, Orlando, FL March 2005. Preprints will be available upon request.

KEYWORDS: optical ceramics, aluminum oxynitirde, spinel, ceramic machining, process improvement, manufacturing technology

A06-025 TITLE: <u>Novel Characterization and Measurement of Radar Ground Clutter for Modeling and Simulation</u>

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop novel technologies and techniques for efficient and cost-effective radar ground clutter measurements and characterization for use in weapon system simulations.

DESCRIPTION: Radar ground clutter measurements are often captured through the use of airborne sensing platforms used in captive flight tests (CFTs) and synthetic aperture radar (SAR) measurements. Clutter backscatter measurements are also conducted using tower or vehicle portable instrumentation radars that measure clutter backscatter on patches of local environments. Measurement of clutter radar backscatter using these methods are severely limited in diversity of look angle, frequency, and spatial location due to cost, sensor access, and measurement logistics. However, modern weapon system simulations require wide ranges of backscatter information in order to fully test sensor performance. Priority is for the development of efficient and cost-effective technologies to support the required measurement clutter diversity for weapon system simulations. Validity of measured values and integration into sensor simulation environments must be considered.

PHASE I: Demonstrate the feasibility of innovative approaches to ground clutter measurement and characterization. Develop concepts and techniques for utilizing, extracting, extrapolating, and modeling such measured clutter information in support of high fidelity sensor simulations. Validity of proposed techniques and subsequent measured clutter backscatter should be addressed.

PHASE II: Develop concepts and initial demonstrations into an operational system that efficiently measures and generates extensive backscatter clutter datasets. Develop and document a validation process to ensure quality and applicability of measured backscatter values. Develop modeling processes to fully characterize diverse clutter backscatter properties for use in weapon system simulations.

PHASE III: Effective and efficient radar ground clutter characterization and measurement has the potential to be used in many military and commercial areas. Potential commercial uses include remote sensing for environmental monitoring and site preparation or selection for ground based radars. Potential military uses include weapon system seekers, targeting systems, and automatic target recognition and acquisition systems.

REFERENCES:
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KEYWORDS: Radar, Backscatter, Ground Clutter, Measurement Systems, Modeling, Simulation

A06-026 TITLE: <u>Metrology for Aspheric Domes</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The goal of this topic is to develop methods or techniques to measure optical figure on an aspheric dome and the associated corrector optics.

DESCRIPTION: Traditional optical seeker systems have spherical domes and only mildly aspheric optics in the optical train. For faster missiles, the spherical dome is a less than desirable shape due to the aerodynamic drag. Aerodynamic domes, commonly referred to as conformal domes, decrease the drag on the missile resulting in increased speed, range, or payload. Conformal shapes could also be used to reduce thermal effects or in low observable applications. The ability to design and build the conformal dome and associated corrector optics has already been demonstrated however, the ability to measure the conformal optics is limited. Recent efforts have extended the metrology capability to optics with departures from a best fit sphere of 50-100 microns. The conformal dome and optics may have departures on the order of millimeters. This topic is designed to provide the metrology to measure this new class of optics.

PHASE I: Evaluate the feasibility of measuring the transmitted wavefront on a conformal dome with a height to diameter ratio of 1.0. The measurement technique should be demonstrated on a hemispherical surface that can also be measured using conventional interferometry.

PHASE II: Demonstrate the ability to measure the transmitted wavefront on conformal dome with a height to diameter ratio of at least 1.0. The measurement should be demonstrated on a dome with a minimum base diameter of 2.75”.

PHASE III: The ability to measure conformal optics will open the design space for high performance military systems requiring high speed optical seekers or conformal windows on aircraft. In addition, applications in other areas such as astronomy or medical instrumentation may benefit from the ability to make and measure these optics.

REFERENCES:
1) Harris, Dan, "Material for Infrared Windows and Domes," ISBN 0-8194-3482-5, SPIE Press, 1999.

KEYWORDS: metrology, conformal optics, aspheres, manufacturing process

A06-027 TITLE: Multi-functional Polymers for Composite Structures

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop a multi-functional polymer for composite missile structures that integrates high thermal and electrical conductivity. The material system should employ state of the art processing parameters for filament winding and/or fiber placement. The electrical and thermal conductivity should be an integrated part of the composite to decrease weight and reduce system cost.

DESCRIPTION: The high specific strength of polymer composite materials offers significant advantages to tactical missile systems. Enhanced through-thickness thermal conductivity in composite structures would enable insensitive munitions (IM) compliant design (slow and fast cookoff). State of the art (SOTA) composite materials require costly and time consuming post processing including the application of conductive coatings to provide electrical conductivity. The challenge lies in incorporating electrically and thermally conductive matrix materials into SOTA composite processing parameters. Currently, the loading of nano-fillers for conductivity increases the viscosity of the matrix resin to a level that is not conducive to filament winding and other automated composite manufacturing techniques.

PHASE I: Perform screening analyses to identify and test various resins, fillers and dispersion processes for use in filament winding resins and/or pre-preg carbon fiber tow. Arbiters for selection should include processability, thermal/electrical properties and mechanical performance characteristics. Down select, through coupon/sub-scale testing, to the most promising materials systems and processing parameters capable of providing polymer composites with an electrical resistivity of less than 0.15 ohm-inch and a thermal conductivity of 20 W/m °K at room temperature. Characterize mechanical properties with the goal of achieving equivalent performance to conventional, non-conductive epoxy systems.

PHASE II: Using the output information from Phase I, develop analytical models for IM cookoff and thermal management systems. Develop prototype/analog representatives of tactical missile structures (e.g., motor cases, airframes) using the analytical models developed. Prototype structures shall include, but are not limited to, pressure vessels/ tubes and flat laminates. Additional required test articles shall be defined based on offerer-identified key performance parameters for proposed solutions. Establish processing parameters, and fabricate components. Verify electrical continuity, enhanced thermal conductivity, and mechanical properties of the composite. Document materials characterization and materials processing techniques.

PHASE III: Multi-functional composite materials will improve IM performance and reduce inert weight in 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. The technology will also lead to understanding of micromechanical interactions within a structure as an enabler of tailoring mechanical, thermal and electrical properties.

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2) Martin, C. A. et.al., "Formation of Percolating Networks in Multi-Wall-Carbon-Nanotube-epoxy Composites", Composites Science and Technology 64, 2004, 2309-2316.
3) Peters, Humphrey, Foral, "Filament Winding Composite Structure Fabrication", 6th Edition, Society for the Advancement of Material and Process Engineering, 1991.

KEYWORDS: nano-composites, filament winding, composite materials, composite manufacturing processes, polymer, fillers, manufacturing technology electrical conductivity, thermal conductivity, missiles

A06-028 TITLE: Manufacturing and Producibility of Gelled Propellants

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Demonstrate that gelled propellants can be made reproducibly with a projected long shelf-life.

DESCRIPTION: Significant attention has been given to gel bipropulsion systems during the last 25 years, resulting in flight test, low temperature operation, and Insensitive Munition (IM) demonstrations. Little attention has been given to the manufacturing and producibility of gel formulations. This program will establish the manufacturing and producibility requirements of gelled fuels and oxidizers, including at least: quality control testing, mix-to-mix variability, accelerated aging, and material compatibility.

PHASE I: Perform an analysis of the cradle-to-grave properties of gelled propellants to establish requirements that will assure that these materials have the stability, reliability, and material compatibility needed for a deployed system. Candidate tests will be identified to assure that the gels will have consistent and reliable properties throughout their life cycle. These include, but are not limited to, tests to qualify gels for manufacturing quality control, long-term storage, transportation, temperature cycling, and demilitarization. The quality control tests that will be considered include, but are not limited to, syneresis, density, yield stress, storage modulus, loss modulus, and interfacial tension with air and nitrogen. The end product of the Phase I effort will be an outline of a life cycle model for gel propellant properties that identifies the crucial properties for which requirements must be set.

PHASE II: Fuel and oxidizer gel formulations will be identified by the Army as baseline propellants for Phase II. Quality control procedures will be established that discriminate between standard and anomalous propellant batches and have low (<10%) two-sigma error bands. These propellants are time-dependent, non-Newtonian fluids; therefore, these tests must be highly automated to minimize operator error. Long-term (20-year) material compatibility requirements will be established for all materials within the hermetically sealed tanks. Short-term (10-minute) compatibility requirements will be established for those materials that are only wetted during flight. Test procedures will be established for these requirements. Accelerated aging tests will be developed that characterize temperature cycles and material stability of gelled propellants expected during a missile's lifetime. Shock and vibration tests will be established to assure that the gel properties will not be degraded by transportation and handling. Other testing will most likely be required that will be identified during Phase I and Phase II. The end product of the Phase II effort will be a proven life cycle model for gel propellant properties that include requirements and specifications.

PHASE III: Gel bi-propulsion systems can be used by NASA for launch vehicles, spacecraft, and satellites. They are applicable for simple boosters as well as where variable thrust is required. The increase safety of gels over hypergolic liquids decreases the hazards of manned space flights and ground operations. For instance, a single engine could be used for changing from low to high earth orbit as well as precision positioning of the satellite for operational purposes, such as detecting leaking dams or mapping crop infestations. Gel propulsion can also be for Air Force, Navy and MDA applications.

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(3)Carl Boyars and Karl Klager (symposium Chairmen), “Propellants Manufacture, Hazards, and Testing,” Advances in Chemistry Series 88, American Chemical Society, Washington D.C. 1969.

(4)Stanley F. Sarner, “Propellant Chemistry” Reinhold Publishing Corporation, New York, 1966.

(5)Gabriel D. Roy (editor), “Advances in Chemical Propulsion,” CRC Press, New York, 2002.

KEYWORDS: fuel gel, oxidizer gel, gel propellant producibility, gel propellant manufacturing, gel propellant life-cycle, material compatibility, quality control

A06-029 TITLE: Hybrid Composite for Beryllium Replacement in Missile Defense Interceptors

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Exo-Atmospheric Product Office, MDA, Joint Program Office

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 development of hybrid composites that can serve as replacements for beryllium components that are safe (nontoxic), reliable, cost effective, and efficient. In addition, such composites could provide for improved heat dissipation, electromagnetic interference shielding, and radiation hardened electronics and optics for missile (Exoatmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor).

DESCRIPTION: Beryllium is a unique metal because of its light weight, high stiffness, high melting point, superior electrical and thermal conductivity as well as other properties. It is used extensively in aviation and missile structures. However, many factors are driving a great need to find a replacement for beryllium including its cost, toxicity, availability, long lead times, and impending Occupational Safety and Health Administration (OSHA) changes concerning production of this material. Previous work sponsored by the Navy (1980 - 1995) showed substantial progress in developing a replacement for beryllium for certain structural applications. That research demonstrated the possibility of developing composite materials with similar properties to beryllium, and this program will build upon that work, using the new approach of hybrid composite technology. Advanced hybrid composites could serve as replacements for beryllium components if their properties are optimized. In addition, such composites could be tailored for various other missile component applications including high thermal conductivity electronic packaging, electromagnetic interference shielding materials, and coatings or components to improve radiation hardening. The superior properties of these composite components may also lead to improved nuclear survivability and functioning after prolonged periods in battlefield/storage environments by reducing shock, vibrations, and thermal stresses. In missiles, the composites could be used in various structural components, housings, seeker optics and mirrors, and electronic packaging. Hybrid composites hold the promise of replacement of beryllium and its alloys with no additional component cost and net zero mass increase. Such materials could be important for a wide range of aviation and missile applications.

This research will involve the development of advanced hybrid composites for replacement of beryllium components as well as provide components with improved thermal dissipation performance, electromagnetic interference shielding, and radiation hardening for missile (Exoatmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor) optics and electronics.

PHASE I: Explore the concept and development for a beryllium replacement using a hybrid composite material. Produce test coupons of the material and measure relevant properties. Provide a feasibility study that addresses cost, service methods, safety, reliability and efficiency. Perform a manufacturability analysis and cost benefit analysis of deployment showing that the structure can be produced in reasonable quantities and at reasonable cost and yields, based on quantifiable benefits, by employing techniques suitable for scale up. Provide a report on scalability, performance characteristics, anticipated yield, and volume costs.

PHASE II: Based on the results and findings of Phase I, implement the technology, fabricate, and test a prototype on a representative missile structure with the hybrid composites. Demonstrate the system's viability and superiority under a wide variety of conditions typical of both normal and extreme operating conditions. Utilize structural analysis software to analyze this new class of composites. Demonstrate scalable manufacturing technology during production of the articles.

PHASE III: Verification of overall approach. Provide a final design for an innovative hybrid composite structure that will provide for nuclear survivability. The proposed technology under this effort would advance the state-of-the-art in aerospace and missile structural performance (Exoatmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor), safety, life extension, preventative and other maintenance, enhanced turbine blade performance for wind energy production in low speed/turbulent conditions, earthquake resistant buildings, deformable hydrofoils for high performance submersibles, and in a spectrum of other areas, for both the government and private sectors. Demonstrate commercial scalability of the manufacturing process and the implementation of the software-based design tools for the commercial development and deployment of advanced structures. Commercialize the technology for both military and civilian applications.

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KEYWORDS: Hybrid composites, nanotechnology, beryllium replacement, radiation hardening, electromagnetic interference shielding, manufacturing engineering, metal-matrix composites

A06-030 TITLE: Anti-Tamper Active and Passive Sensors for Use Inside an Integrated Circuit

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: Develop sensor technologies suitable for use inside an integrated circuit to monitor for tampering events.

Sensors for electromagnetic, optical, X-ray, Terahertz Ray (T-ray), magnetic, acoustical, etc. are desired. Integration of active and passive sensors is desirable. Sensor technologies include: optical waveguides, phase gratings, photodetectors, charge coupled devices (CCDs), microelectrical mechanical systems (MEMS), radio frequency (RF) detectors, etc.

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. This effort will focus on identifying sensors technologies and protection techniques that will delay reverse engineering and exploitation, slowing an adversary as much as possible in compromising U.S. technologies when they fall under their control. To date, much Government and industry effort has focused on passive board/chip coatings and self-destruct concepts, but as the U.S. Army and DoD AT organizations have evaluated them, the effectiveness and PEO and PM acceptance of these types of techniques has been limited. Other concepts that have been assessed by the AT community include manufacturing processes, obfuscation, encryption, active coatings, volume protection and other such techniques, and these and others would certainly be valid areas for further study. 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: Design and analyze novel anti-tamper sensors for use inside an integrated circuit. The sensors shall monitor for magnetic fields, electromagnetic waves, x-rays, etc. and tamper events. The system shall identify events, and threat level, and act upon the event. The tamper events shall be identified, threat level determined, and acted upon. Contractor shall demonstrate a prototype working sensor package suitable for use inside an integrated circuit.

PHASE II: Contractor shall design and analyze an integrated circuit with a prototype anti-tamper sensor system inside. Contractor shall have an independent verification and validation done to test the anti-tamper features of the integrated circuit.

PHASE III: Contractor shall design and analyze a full production level integrated circuit with an anti-tamper sensor package. It is desirable that the contractor team with a prime contractor to develop a final production integrated circuit for use in a fielded system. Contractor shall have an independent verification and validation done to test the anti-tamper features of the integrated circuit. Contractor shall evaluate anti-tamper sensing technology for use in commercial applications, self monitoring applications, and safety critical systems.

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KEYWORDS: Information technology devices, Anti-tamper, sensors, optics, T-ray, X-ray, magnetic, electromagnetic, integrated circuit

A06-031 TITLE: Affordable Electro-Magnetic Interference (EMI) Grid Application

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this effort is to develop a low cost method of applying a rectangular grid pattern to the concave surface of a dome that could be used in missile applications.

DESCRIPTION: Current methods of applying a repeatable rectangular grid pattern on domes are time consuming and expensive. The goal of this effort is to develop and demonstrate an economical production method of applying a grid consisting of 15 mil squares. The line width of the grid should be 1 mil or less and have a thickness that will result in a resistance of less than 1 ohm per square. The grid is to be applied to the inside (concave surface) of a hemispherical dome having a diameter of 7 inches.

PHASE I: The goal of this phase is to develop a low cost, repeatable method of applying a grid to the inside diameter of a hemispherical dome. The grid is to consist of squares approximately 15 mils on a side, have a line width of approximately 1 mil or less and a thickness that will result in a resistance of approximately 1 ohm or less per square. The results of the development effort will be presented to the Government for evaluation

PHASE II: Refine the developed method so that it is consistently capable of applying a grid consisting of 15 mil squares having a line width of 1 mil or less and a thickness that will result in a resistance of 1 ohm or less per square. The grid is to be applied to the inside (concave surface) of a hemispherical dome having a diameter of approximately 7 inches. The reliability the application process will be demonstrate the process by producing 20 samples that will be provided to the Government for evaluation of process consistency. Target production rate is 10,000 domes per year.

PHASE III: A number of new sensor systems desire/require electro-magnetic interference (EMI) protection. The development of an affordable EMI grid application method will greatly improve the affordability of future missile systems.

REFERENCES:
1) Harris, Dan, "Material for Infrared Windows and Domes," ISBN 0-8194-3482-5, SPIE Press, 1999.
2) Kirsch, James C, et al, Tri-Mode Seeker Dome Considerations, Window & Dome Technologies and Materials IX, Proceedings of the SPIE, Orlando, FL March 2005. Preprints will be available upon request.

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

A06-032 TITLE: Software Sentinel Anti-tamper Technique

TECHNOLOGY AREAS: Information Systems, 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 contractor shall investigate an improved software sentinel anti-tamper (AT) technique using secure inter-process communications. A software sentinel is a software-based anti-tamper technique. Software sentinel(s) (or software agents) monitor system timing, the contents of computer files and binaries to verify the integrity of the software and the sentinels. Typically, multiple software sentinels are used to make defeating the software protection more difficult. Part of the software sentinel’s protection mechanism is the ability to communicate between sentinels to monitor and verify the integrity of the sentinels. It is desired to strongly connect the communications of the sentinels. The goal is to allow all the software sentinels to communicate with each other through a single shared memory variable concurrently (simultaneously).

In each software sentinel, a hashing function may be used to compare decrypted data without requiring storage of unencrypted plaintext. Common hashing functions include: secure hashing algorithm 1 (SHA1) and message digest 5 algorithm (MD5).

One possible technique, for a shared memory variable to allow all software sentinels to be strongly connected and simultaneously communicate, is through linear functions. A linear function is a function with the mathematical properties of (1) $g(ax) = ag(x)$ where 'a' is a real constant, x is a variable, and g(x) is a function; (2) $g(ax) + h(bx) = ag(x) + bh(x)$ where 'a' and 'b' are constants, x is a variable and g(x) and h(x) are functions. Spread spectrum communication is an example of a technique satisfying a linear function. Multiple spread spectrum signals are able to simultaneously use the same frequency band. All spread spectrum signals can be recovered with the appropriate de-spreading code. Spread spectrum is also used for secure communications.

The goal is to develop a secure inter-sentinel communications technique based on a single shared memory variable allowing all software sentinels to concurrently (simultaneously), securely communicate. More complex coding schemes: digital watermarking, wavelets, nonlinear functions, pseudo-random sequences, ranging codes, or chaotic systems, etc. may be used. The concept is to concentrate as much complexity as possible into a small space. It may also be beneficial to consider hardware acceleration.

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.

This effort will focus on software sentinels and secure inter-sentinel communications to create a new software anti-tamper technique. A software sentinel is a software-based anti-tamper technique. Software sentinel(s) monitor system timing, the contents of computer files and binaries to verify the integrity of the software and the sentinels. Typically, multiple software sentinels are used to make defeating the software protection more difficult. Part of the software sentinel’s protection mechanism is the ability to communicate between sentinels to monitor and verify the integrity of the sentinels.

To date, much Government and industry effort has focused on passive board/chip coatings and self-destruct concepts, but as the U.S. Army and DoD AT organizations have evaluated them, the effectiveness and PEO and PM acceptance of these types of techniques has been limited. Other concepts that have been assessed by the AT community include manufacturing processes, obfuscation, encryption, active coatings, volume protection and other such techniques, and these and others would certainly be valid areas for further study. 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: The contractor shall investigate and analyze a new and innovative software anti-tamper technique(s) based on software sentinels and secure inter-sentinel communications as described in the objective section. A mechanism to monitor system and software sentinel timing shall be included. The focus should be on denying an adversary access to details about the system's software (primary objective) and hardware (secondary objective). A simulation demonstrating the operation of the software sentinels is desirable.

PHASE II: The contractor shall demonstrate a working software anti-tamper system based on software sentinels, and secure inter-sentinel communications as described in the objective section with software, hardware, and an operating system. The contractor shall have an independent verification and validation team analyze the effectiveness of the anti-tamper technology.

PHASE III: The contractor shall complete a production level version of software anti-tamper system based on software sentinels, and secure inter-sentinel communications as described in the objective section with software, hardware, and an operating system. The contractor will look into teaming with a prime contractor to integrate the new technology into a current production system. The contractor shall have an independent verification and validation team analyze the effectiveness of the anti-tamper technology. The contractor shall investigate the potential of a commercial technology derived from the above.

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KEYWORDS: Information technology devices, software anti-tamper, software sentinels, spread spectrum, pseudo-random (PN) sequence, turbo codes, ranging codes, encryption, and decryption.

A06-033 TITLE: Improvements in Yttria Strength for Durable Windows

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The goal of this topic is to develop methods or techniques that will provide a 2x improvement in strength for yttria windows.

DESCRIPTION: Yttria has very desirable transmission properties for infrared windows and domes. The transmission window for yttria goes well beyond that for aluminum oxynitride, spinel, or sapphire offering the potential for longer wave applications and the best use of the mid-wave spectrum. The drawback to yttria has always been its low strength and poor thermal conductivity. Various efforts have been undertaken to improve the strength of yttria by reducing the grain size. These efforts have failed to produce small grain yttria with acceptable transmission properties. Recently published work on improving the strength of aluminum oxynitride has reported tremendous increases in strength through a combination of post firing steps such as careful optical surface finishing. The purpose of this effort is to demonstrate a 2x improvement in the strength of yttria through a similar approach. Proposals that focus on reducing grain size rather than post processing of conventional large grain yttria will be considered non-responsive to the topic.

PHASE I: Evaluate the feasibility of improving the strength of yttria through post processing steps such as careful surface finishing on conventional large grain material. Feasibility of the approach should be demonstrated by comparing biaxial flexure strength measurements on small samples of both conventional yttria and conventional yttria with improved surface finishing or other post firing steps. A minimum of six 19 millimeter diameter samples of both conventional yttria and post processed yttria will be tested for both strength and transmission.

PHASE II: Demonstrate a minimum 2x improvement in strength over conventional yttria through the processes developed in Phase I.   The desired strength is 250 megapascal (MPa)with a Weibull modulus of 8. Success will be demonstrated by comparing biaxial flexure strength on 25 millimeter diameter coupons. Enough coupons (approximately 25-30) will be measured to obtain the Weibull modulus. Four 3” diameter domes using the same post processing techniques will also be provided to show applicability of the finishing techniques to curved surfaces and for possible thermal shock tests.

PHASE III: High strength yttria windows would find applications in high speed missile applications as a lower cost alternative to sapphire.

REFERENCES:
1) Harris, Dan, "Material for Infrared Windows and Domes", ISBN 0-8194-3482-5, SPIE Press, 1999.

2) Warner, Charles, et al, “Characterization of ALON Optical Ceramic, Window & Dome Technologies and Materials IX, Proceedings of the SPIE, Orlando, FL March 2005”.

KEYWORDS: optical ceramics, infrared windows, domes, yttria, manufacturing process, process improvement

A06-034 TITLE: Hardware-Based Anti-Tamper Techniques

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Design and implement new hardware anti-tamper (AT) techniques that can be employed to delay or make economically infeasible the reverse engineering or compromise of U.S. developed technologies utilized in U.S. Army weapon systems.

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. This effort will focus on identifying new hardware design and protection techniques and technologies that will delay reverse engineering and exploitation, slowing an adversary as much as possible in compromising U.S. technologies when they fall under their control. To date, much Government and industry effort has focused on passive board/chip coatings and self-destruct concepts, but as the U.S. Army and DoD AT organizations have evaluated them, the effectiveness and PEO and PM acceptance of these types of techniques has been limited. Other concepts that have been assessed by the AT community include manufacturing processes, obfuscation, encryption, active coatings, volume protection and other such techniques, and these and others would certainly be valid areas for further study. 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: The contractor will design and analyze the effectiveness of new and innovative anti-tamper techniques/technologies to protect weapon system critical components. The focus should be on denying an adversary access to details about radio frequency electronics such as solid-state transmitters, receivers, oscillators, and monolithic microwave integrated circuits (MMICs), or digital components such as analog-to-digital (A/D) converters, application specific integrated circuits (ASICs), and field programmable gate arrays (FPGAs).

PHASE II: Based on the Phase I effort, the contractor shall further develop and incorporate the hardware anti-tamper techniques/technologies into a prototype. A required Phase II deliverable shall be a prototype of the anti-tampered hardware module(s), along with documentation of the hardware AT technique, to allow for Government assessment of the techniques in preventing compromise of critical software.

PHASE III: The U.S. faces both military and economic threats to its technological advantage, thus providing good potential for an offeror to commercialize a successful Phase II effort. The intent of the Phase III effort will be to take the Phase II product and secure non-SBIR funding, Government or private sector, to develop it into a viable product. If accomplished, the product should have ready customers throughout the weapons system, electronics, aviation, space and other such markets for inclusion in technology protection applications for products developed for the U.S. military.

REFERENCES:

1) Wills, L., Newcomb, P., Eds. Reverse Engineering, Kluwer Academic Publishers, 1996.
2) Ingle, K. A. Reverse Engineering, McGraw-Hill Professional, 1994.
3) Furber, S., ARM System-on-chip Architecture, Addison-Wesley, 2000.
4) Maxfield, C. The Design Warrior’s Guide to FPGAs, Newnes, 2004.
5) Huang, A. Hacking the Xbox: An Introduction to Reverse Engineering, No Starch, 2003.
6) Fullam, S. Hardware Hacking Projects for Geeks, O'Reilly, 2003.
7) Grand, J., Russell, R., Mitnick, K. Hardware Hacking: Have Fun While Voiding Your Warranty, Syngress, 2004.
8) Menezes, P., Oorschot, V., Vanstone, S. Handbook of Applied Cryptography, CRC, 1996.

KEYWORDS: Anti-Tamper, Reverse Engineering, Electronics, Self-Destruct, Energetics, Material Coatings, Active Coatings, Solid State Transmitter, Receiver, Oscillator, Microwave Monolithic Integrated Circuit (MMIC), Analog-to-Digital Converter (ADC), Application Specific Integrated Circuit (ASIC), Field Programmable Gate Array (FPGA), Exploitation, Hacking, Cryptography, Transceiver, System-on-a-Chip, Crypto Key-Management

A06-035 TITLE: Assessment Tool for Determining Product Assurance Readiness Levels

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: To determine the feasibility and develop a prototype for a model to determine Product Assurance Readiness Levels for use in determining best value in weapon system acquisitions.

DESCRIPTION: The acquisition of quality and reliable weapon systems relies on the use of mature Product Assurance Systems. Analysis of these systems requires the use of disparate pieces of knowledge and information from numerous sources that must be synthesized by the product assurance and manufacturing engineer in order to make sound decisions and predictions. Furthermore, this knowledge and information varies widely from weapon system to weapon system, process to process, and data collection and assessment methodology. The decisions on product assurance readiness are similar but vary widely. A decision aid potentially in the form of an expert system is needed to accumulate product assurance and manufacturing lessons learned from various weapon systems, perform analysis on the available data, assign risk levels, and determine the overall product assurance readiness levels. This tool will facilitate best value acquisition programs and serve as a repository for data and data base management tools.

PHASE I: The initial phase of this SBIR is to evaluate a broad range of product assurance readiness knowledge, information, and data to determine the feasibility of developing a total product assurance readiness decision making aid. Sources of this knowledge, information and data will be identified and screened to provide the critical sources. An initial model will be developed during this phase. This model will be an AMRDEC Web Based Portal site used to prototype a limited number of specific product assurance readiness level decisions. Model must provide a comprehensive, graphical multi user interface which is compatible on the Aviation & Missile Research, Development, and Engineering Center (AMRDEC) network. Model must allow for data download/input and sorting by pre-approved users dependent on task function.

PHASE II: A complete model prototype will be developed during Phase II and validated using information from an actual weapon system project. The complete prototype will include a larger set of supported decisions and risk level assessments (to be selected by the SBIR team). In addition, the complete prototype will autonomously (while the model is running) notify the user of potential issues and provide risk level assignment and suggested courses of action and best practice approaches. Additional capabilities will allow the prototype to link to relevant data in libraries and external assessment information. (to be selected by the SBIR team).

PHASE III: The model will be capable of performing product assurance readiness level assessments and tracking for any complex weapon system or acquisition program. The model can be applied to complex equipment, vehicles, aircraft, and spacecraft.

REFERENCES:
1) Missile Defense Agency, Engineering Manufacturing Readiness Levels (EMRL) Implementation Guide.
2) DoD Deskbook 5000.2-R, Appendix 6, Technology Readiness Levels and Their Definitions.
3) Defense Procurement and Acquisition Policy, Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment, Version 1.0, Jan 31,2003.

KEYWORDS: Product Assurance Readiness/Analysis, Decision Making Tools, Project Tracking ,manufacturing quality, quality systems

A06-036 TITLE: Multifunctional Nanodevice Skins for Cognitive Missiles

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: Exo-Atmospheric Product Office, MDA, Joint Program Office

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 development of nanodevice skins for generalized surfaces (planar or non-planar, stiff or flexible, fixed and morphing) and interlayer integration to be used for multifunctional, multi-purpose sensing, actuation, control, transmission, and feedback in cognitive missiles and other air vehicles.

DESCRIPTION: The primary objective is the development of a nanoscale deposition technique or suite of approaches that provides for passive and active circuit component manufacturing to be used in missiles and other air vehicle multifunctional skin applications. Manipulation at the nanoscale promises untold capabilities in enumerable areas both commercial and military. Specific advantages of the miniaturization of electronic circuits and components in missiles and air vehicles lie in the potential to integrate these devices into surface layers or sub-surface layers without impacting structural integrity or aerodynamics. This seamless integration allows for multifunctional skins that combine sensing, actuation and control while at the same time supporting load-bearing, self-healing, conformal or morphing functionality. Advantages to nanodevice skin integration also include increased payload, increased internal real-estate as well as concealment. Investigation of nanomaterials and nanostructures such as nanotubes, nanoparticles, nanowires, nanocomposites and spintronic devices as well as low-cost Micro, and Nano Electro Mechanical systems (MEMS and NEMS) fabrication approaches that enable scaled-up processing are also of interest. A smart nanoskin would be one that localizes sensing, actuation and control functions at the nanoscale.

Advanced fabrication processes and manipulation at the nanoscale promise smart skin technology with numerous possibilities. Preferred functions are manufacturing of nanodevices that, due to size, can be integrated into both structural and flexible components, where the Young's modulus of the components can vary between 5 GPa and 70 GPa. Examples of nanodevice integration into components include insertion into aircraft parts or skin to measure structural state as well as integrated onto surfaces to perform the signal processing for conformal antennas. Envisioned is a "smart" multifunctional surface or sub-surface possessing distributed sensors over a large area, measuring, for example, strain between 0.001 and 10,000 microstrains or temperatures between 18°C and 190°C while consuming power 100 mW or less. These electronic components would support feedback control functionality enabling missiles and air vehicles that can sense and respond. Device package thicknesses less than 0.25 mm would minimize any unwanted moldline stepping.

PHASE I: Explore the nanoscale approaches for manufacturing of circuit components for multifunctionality and multi-purpose sensing, actuation, control, transmission, and feedback in cognitive missiles skins. Provide a feasibility study that addresses the reliability of the method(s) selected. Identify the optimal materials and deposition techniques for mild to extreme operating conditions (nuclear environment, temperature, shock loading, etc). Provide report detailing findings.

PHASE II: Based on the results of the feasibility study in Phase I, develop a prototype circuit on a representative structure such as a missile or air vehicle. Demonstrate the system's viability and superiority under a wide variety of conditions typical of both normal and extreme operating conditions. Develop performance metrics for cognitive missiles. Demonstrate scalable manufacturing technology during production of the articles. Provide report.

PHASE III: The development of integrated miniaturized electronics will have broad applications for both military and commercial sectors. For military applications, there is a need for high-performance electronic components such as sensors requiring less power and minimal volume that are at the same time conformal and integrated. In commercial applications, there is an increasing demand for miniaturization of components for portable consumer products benefiting from advances of reduced size, weight, integration such as personal computers and other microprocessor-driven devices, cell phones, displays, global positioning system devices, etc. The proposed technology under this effort would advance the state-of-the-art in missile structural performance (Exoatmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor), safety, life extension, preventative and other maintenance, enhanced turbine blade performance for wind energy production in low speed/turbulent conditions, earthquake resistant buildings, deformable hydrofoils for high performance submersibles, and in a spectrum of other areas, for both the government and private sectors. Advanced multifunctional warfighter uniforms and other textiles will also be of interest.

REFERENCES:
1) C. Charitidis and S. Logothetidis, "Nanoscale effects on the nanomechanical properties of multifunctional materials", Computational Materials Science, 33(1-3) 296-302, April 2005.
2) C. Martin, J. Grisolia, L. Ressier, M. Respaud, J. P. Peyrade, F. Carcenac and C. Vieu, "Fabrication of nanodevices for magneto-transport measurements through nanoparticles", Microelectronic Engineering, 73, 627-631, June 2004.
3) Ahmed K. Noor, Samuel L. Venneri, Donald B. Paul and Mark A. Hopkins, "Structures technology for future aerospace systems", Computers & Structures, 74(5) 507-519, February 2000.

KEYWORDS: nanoscale, nanodevice skins, nanomaterials, smart, non-planar, distributed, Micro and Nano Electro Mechanical systems, cognitive structures, manufacturing materials

A06-037 TITLE: <u>Near Real Time Structure Mapping for Urban Combat</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design, develop and demonstrate the algorithms, hardware, and software components required to perform automated mapping of the internal 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 in which urban combat is expected 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 system (UMS) which can be inserted into the 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 sonar, multi-sensor processing and 3-D image reconstruction algorithms and processing architectures suitable for autonomous mapping of internal building structures 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. Demonstrate a proof of principle of the design by showing a mission thread which allows a soldier/UMS collect structure 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, ARDEC-supplied Small Unit Situational Awareness architecture. The component must be capable of seamless integration and operation within the ARDEC-supplied architecture, which is component-based. Conduct testing to demonstrate feasibility of the component for operation within a steel and concrete urban environment.

PHASE III: The algorithms and software developed under this effort will have dual use applications in all domestic security operations where detailed, individual-level situation awareness in urban incident response is required. 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 rescue operations in collapsed buildings and structures. Local, county, state and federal SWAT teams can also use this capability and technology for SWAT operations. 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) Army/Marine Corps Ground Robotics Master Plan, Users Force Operational Capabilities/Future Naval Capabilities. 2005.
3) Politis, Z. & Smith, P. J. P. (2001). Classification of Textured Surfaces for Robot Navigation Using Continuous Transmission Frequency-Modulated Sonar Signatures. The International Journal of Robotics Research, February 1, 2001; 20(2): 107 – 128.
4) Kao, G. & Probert, P. (2000). Feature Extraction from a Broadband Sonar Sensor for Mapping Structured Environments Efficiently. The International Journal of Robotics Research, 2000; 19: 895-913.

KEYWORDS: Situational awareness, Structure mapping, Collaborative data, Unmanned systems

A06-038 TITLE: <u>Low Cost, Improved Thermal Batteries</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: To develop thermal batteries that are lower in cost, improved in electrochemical performance, and can be made in three-dimensional shapes.

DESCRIPTION: There exists a growing need for thermal (and other primary) batteries that have very long shelf life, and can be made into variable and conformal shapes. Lower cost and high reliability is also desirable. Unfortunately, present manufacturing processes used to make thermal batteries make it difficult to meet these goals (1). Fabrication usually involves batch processes, including pressing electrodes and electrolyte into rigid wafers, and assembling batteries by hand (2). The batteries are encased in a hermetically-sealed metal container that is usually cylindrical in shape. Devices using the batteries must accommodate the (non-ideal) battery shape and size.

Thermal batteries made using pressed layers are not optimum in their design, due to limitations in the processing. For example, electrodes and/or electrolyte layers must be sufficiently thick to avoid cracking during the pressing steps; however, this creates excessive internal resistance and can require excess material, beyond what is ideally needed for a given duty. Excessively thick layers can also cause thermal and current misdistribution during transient operation, which can lower performance or limit life.

Improvement in thermal batteries has been slow, as producers have had little motivation to invest research funds for a low-volume product (1). However, recent reports (3,4) have described thermal batteries that are conformal; i.e., can be made into curves or other three-dimensional shapes. Most of these approaches involve continuous processing, that would at once lower the production cost, and allow cell designs that allow improved performance. Improved, lower-cost, conformal thermal batteries will improve the performance of new generations of smart munitions that require improved power sources.

Proposals are sought to address the need for improved thermal batteries, made with low-cost continuous processes, and that can possible be made into three-dimensional shapes. Emphasis should also be given to improvements in electrochemical performance (energy density, discharge potential, power output) as well as process improvements. Further, the focus should be on the cell sandwich itself (electrodes, separator) rather than the support hardware (cell container, connections, pyrotechnic, igniter, etc.). Processes for making key battery materials will also be considered. It is desirable, though not required that new cell development be done in conjunction with mathematical modeling to help optimize cell designs.

PHASE I: Design and develop thermal batteries that are made using improved processing concepts. Contrast various processing options that could be used to make the batteries. Compare possible options to factors including but not limited to survivability, required volume, integration issues, power production requirements and efficiency. Demonstrate conformal sub-scale batteries and their electrochemical behavior. From this study down select to candidate technology for transition to Phase II.

PHASE II: Build full-scale multi-cell prototype batteries and test in a relevant environment, Demonstrate the performance of the new thermal battery technology against DOD (and other) thermal battery requirements, and demonstrate survivability in operational environment.

PHASE III: Possibility for application not limited to the realm of munitions. Examples include bore-hole engineering and emergency flares. In general thermal batteries could find commercial uses beyond the strictly military usage, as their manufacturing cost is reduced.

REFERENCES:
1) Macmahan, W., “RDECOM Power & Energy IPT Thermal Battery Workshop – Overview, Findings, and Recommendations,” Redstone Arsenal, U.S. Army, Huntsville, AL, April 30 (2004).
2) Linden, D., “Handbook of Batteries,” 2nd Ed., McGraw-Hill, New York, NY (1998).
3) R. A. Guidotti, F. W. Reinhardt, J. D., and D. E. Reisner, “Preparation and Characterization of Nanostructured FeS2 and CoS2 for High-Temperature Batteries,” to be published in proceedings of MRS meeting, San Francisco, CA, April 1-4, 2002.
4) Delnick, F. M., Butler, P. C., “Thermal Battery Architecture,” Joint DOD/DOE Munitions Technology Program, Project Plan, Sandia Internal Document, April 30, 2004.

KEYWORDS: power, battery, thermal, smart projectile, fuze, power generation, smart munitions, guided munitions, microelectronics, conformal, continuous processing

A06-039 TITLE: Versatile Sensor Network/Data Fusion Optimization System

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a versatile wireless acoustic sensor network development system which will allow the optimization of high performance collaborative data fusion within scalable distributed sensor network architectures.

DESCRIPTION: Acoustic signal processing in battlefield environments has brought enhanced capability to the Warfighter. Most recently, the performance capability of low cost distributed sensor networks to accurately track targets as well as gunfire locations has been demonstrated using 15 to 60 randomly emplaced sensor nodes. The realistic fielding of such systems has been facilitated by the advancement of MESH/Ad-hoc or ZigBee type networked communications system designs which allow scaling such networks to hundreds of sensors. The performance potential and area efficiency of coverage of any network of sensors is directly related to the effectiveness and efficiency of the data fusion approach (or the ability for sensors within the network to effectively share, collaborate, and act on their sensed information).

The optimization of sensor algorithms and hardware/software solutions for high performance data fusion within scalable sensor networks represents a formidable challenge. Unfortunately, most sensor hardware/software solutions emerge in the context of small collaborative networks which do not optimize what can be realized with high performance data fusion or its more efficient implementation in scalable networks. An innovative development approach and wireless system architecture to facilitate the optimization of data fusion for scalable networks is thus desired.

The system architecture should facilitate data fusion algorithm development by allowing the developer to quickly define sensor functionality at each point in the network, juggle the number of sensors involved in a particular data fusion collaboration, vary how much information is shared at each point in the network, and determine how these interrelated factors affect overall system level detection/tracking performance. The system should also be capable of allowing the developer to effectively balance system level performance against realistic hardware/software implementations, as different data fusion designs affect the quantity of information shared, the level of processing and power utilization required at each node in the network, and ultimately the system level detection/tracking performance as it relates to cost per unit area of coverage.

To be effective, the system should consist of a distributed array of at least 40 wireless acoustic sensing/processing nodes capable of communicating over distances of approximately 200 meters between nodes. Nodes should embrace an open architecture that will enable third-party developers to port their software algorithms through downloadable applets that encode, filter, condition, and classify acoustic signals. The design of each node should allow common microphone interface and preamp, a processor to house the sensor processing and data fusion algorithms, computer interface to monitor and reprogram sensor/data fusion algorithms, and communications system. Nodes should be capable of forwarding acoustic processed or unprocessed information over the wireless network to a central processing console. Nodes should be able to time stamp information packets forwarded from each node with a time precision accuracy of less than 1 millisecond. The design of the nodes must accommodate a wide range of potential sensor functionalities, ranging from minimal data fusion collaboration to more complex gateway level data fusion functionality. The central processing console should be capable of performing further signal processing and system level data fusion using third-party algorithms as well as recording all acquired data within the sensor network.

PHASE I: Review existing acoustic algorithms, data fusion approaches, and network architecture designs. Examine commercially available ZigBee or other applicable COTS communications systems. Develop a flexible wireless acoustic network system architecture that will streamline the ability to develop, test, and optimize existing and future battlefield acoustic data fusion algorithms and network architecture designs. Demonstrate essential network functionality by collecting and forwarding real-time acoustic signals to a central processor using no less than 15 acoustic sensor nodes.

PHASE II: Fabricate a prototype wireless acoustic network system capable of sensing, recording, and processing battlefield acoustic events over a large test range with up to 40 node locations with highly accurate time and location stamping at each node. Demonstrate the ability to load and monitor acoustic sensor algorithms at each point in the network. Demonstrate the capability to use system to optimize the data fusion approach and corresponding hardware/software node level design parameters for a given acoustic distributed sensor network application.

PHASE III: Military: Sensor systems and/or munitions systems will be capable of improving their performance and expanding their role on the battlefield with network designs which incorporate optimized data fusion solutions. A wireless acoustic sensor network development system can significantly improve and stream line the development of sensor hardware/software designs, optimizing system performance, and vastly improve the scalability of the network solution. This supports the development of more cost effective and more efficiently distributable acoustic sensor systems for target aiming and gunfire detection.
Commercial: Optimized scalable acoustic sensor networks has high commercial potential and can be easily expanded to other sensor types, exploiting a wide range of security/surveillance applications which feedback exact location of acoustic, seismic, optical (or other) disturbances. Scalability of the solution allows efficient application for wide area Homeland Security/Border Surveillance Efficient scalable and commercial potential is especially facilitated by emerging COTS MESH/ZigBee communications solutions which provide the essential communications

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2) Li, Ekpenyong, Huang “A Location System Using Asynchronous Distributed Sensors”, http://www.ieee-infocom.org/2004/Papers/13_4.PDF
3) Cardoza, Miguel, et. Al, “Offshore Weapon Scoring Using Rapidly Deployed Real-time Acoustic Sensors”, http://www.dtic.mil/ndia/2005test/tk9.pdf

KEYWORDS: Data, Fusion, Scalable, Network, Sensors, Algorithm, Acoustic, Detect, Localization, Distributed

A06-040 TITLE: Innovative Thermal/Chemical Resistant Coating Material

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop an innovative coating material that has good thermal and chemical agent resistance properties.

DESCRIPTION: The use of thermal paint technology has demonstrated successful results on munition systems when exposed to fast cook off (FCO) environments of approx 1500F. However, past research and tests indicated that current thermal resistant paints are incapable of surviving sequential rough handling requirements such as -65F drop test environments. Past technology also failed to show chemical agent resistance. Agents include 1,2,2 – trimethylpropylmethylphosphonofluoridate (aka Soman) and 2,2 – dichlorodiethylsulfide (aka mustard gas). Both of these features are critical in munitions performance throughout the life cycle. Coating failures, specifically at cold temperatures, result in exposed metal. Bare metal is susceptible to corrosive material damage. This SBIR effort is to develop a coating to provide a thermal conductivity no more than 0.1 W/m*K (watts / meter*kelvin), while providing a chemical agent resistance capability as defined by the requirements documents provided in the below references. Most importantly, the coating must provide Insensitive Muntions (IM) enhancement to support a Type V maximum reaction during a Fast Cook Off test in accordance with MIL-STD-2105C. A type V reaction correlates to energetic material ignition and burning non-propulsively, debris staying within area of the fire and no hazardous fragments propelled beyond 49ft. A hazardous fragment is a piece of the reacting weapon, weapons system or container having an impact energy of 79 newton meters (N*M) or greater. Past experience with successful FCO test results revealed coated test panels were able to maintain under 600 degrees F on one side while 2000 degrees F is applied to the opposite side for over 600 seconds.

PHASE I: Design/formulate an innovative thermal chemical resistant coating material based upon the referenced requirements, that can be applied to mild steel, aluminum, or thermoset composite panels, which will provide a thermal conductivity of no more than 0.1 W/m*K, thereby enhancing IM performance of packaged munitions. The performance goal is a Type V maximum reaction for FCO tests where no hazardous fragment is propelled beyond 49 ft. (Note: calculations showing that k=0.1 W/m*K or k<0.1 W/m*K do not in themselves imply the coating will enable packaged munitions to obtain a type V reaction when subjected to a FCO.) Further calculations will be necessary to prove a type V reaction is possible with proposed innovative coating material technology.

PHASE II: Develop the innovative prototype thermal chemical resistant coating material that meets the maximum thermal conductivity of 0.1 watts/meter*kelvin and demonstrate its capability to meet the desired type V FCO IM requirments as defined by the referenced sources.

PHASE III: For military applications, the coating mateiral may be used on future munitions and munition containers. For commercial applications, the coating material may be applied to commercially transported HAZMAT materials and building fire protection. Use of thermal resistance technology may effectively enhance safety and reduce reactions when an accident occurs and a fuel fire results.

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1) United States. Department of Defense. Acquisition Manager's Handbook for Insensitive Munitions. JAN2004 Rev01.
2) "ASTM D522-93A." American Society for Testing and Materials. 2001.
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KEYWORDS: Safety, Fast cook off, slow cook off, IM enhancement, heat resistance, thermal management

A06-041 TITLE: Integration of a Laser Range Finder into a Stabilized Binocular

TECHNOLOGY AREAS: Electronics, Weapons

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design & build an Integrated Laser Range Finder with a Military approved Stabilized Binocular.

DESCRIPTION: One of the most serious problems in the use of handheld laser rangefinders is the jitter associated with the nervous system of the human operator that makes it extremely difficult at ranges of more than a few kilometers to insure that the laser spot is on the actual target rather than located somewhere else entirely. If a miniature powerful eye safe laser rangefinder could be placed on a stabilized platform such as the US Army’s M-25 binocular system, the observer would be able to report target location with respect to his own GPS coordinates with a high degree of accuracy. Therefore calling in air strikes or artillery would have an extremely high kill/hit probability.

The technical objectives associated with this research are:
• Integration of a miniature 1540 nm erbium eye safe laser into the binoculars where the rangefinder is capable of sending a beam out to ~ 5 km. with a return signal strong enough for a good S/N level without placing a high burden on the system power supply.
• Integration of the beam with the existing optics that takes advantage of the stabilization provided by the system to eliminate movement and jitter.
• Development of the system where the rangefinder beam is placed on the target by the use of a reticle in the direct view optics and where this placement is accurate for all levels of system magnification.
• Display of the range through the existing optics with a number easily recognizable by the operator.

PHASE I: Design an integrated laser range finder with a stabilized binocular system.

PHASE II: Develop a prototype of the interated range finder and binoculars.

PHASE III: The military applications are for the future mounted/dismounted battlespace. Commercial applications include Law Enforcement and use in surveying systems where distance and location of a point must accurately known in a quick, inexpensive manner.

REFERENCES:
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2)Nikulin, V., M. Bouzoubaa, V. Skormin, and T. Busch, “Decentralized Adaptive Control for Laser Beam Tracking Systems”, Proc. SPIE Vol. 4272, pp 200-208, 2001.

KEYWORDS: Binoculars, Laser Ranging, Stabilized Optics, Target Location, Distance Measurement

A06-042 TITLE: High Speed Innovative Electronic Image Stabilization

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop an efficient, high-speed multi-spectral electronic image stabilization and super resolution algorithm for multi-spectral sensors.

DESCRIPTION: Smart video systems are becoming increasingly important tools in supporting the Homeland Defense and Security activities. Multi-spectral sensors that detect a variety of targets are now being used on moving platforms such as UAV, UGV, and Armed Robot applications. Such mobile applications require stable video for driving, flying, reconnaissance, surveillance, and reliable target detection, tracking, and recognition. Higher frame rates are also useful in mobile applications such as smart pathfinder and automatic target tracking. With higher frame rates, higher resolution has been demonstrated to be obtained through super-sampling over multiple frames of a video. This SBIR seeks electronic video stabilization and super resolution algorithms that are highly efficient for high-speed applications (greater than 30 fps) and that can be applied to multi-spectral sensor inputs (visual, near-IR, FLIR, Tera-Hz). Existing algorithms are generally sensor specific and require large, power-hungry processors to process in real-time. Gyro-stabilization is both expensive and heavy, limiting certain applications. The purpose of this SBIR is to develop a highly efficient electronics stabilization and super resolution algorithm that can be processed in small electronics. We expect such an algorithm to enable sensors to see further and stabilize video in high-vibration environments on smaller, less powerful electronics.

PHASE I: Design a high-speed multi-spectral electronic video stabilization and super resolution algorithm that is highly efficient for small processing platforms. Clearly show how the algorithm will run efficiently with a high degree of performance. Characterize the stabilization and super resolution algorithm at a variety of frame rates and vibration frequencies and amplitudes.

PHASE II: Optimize the algorithm and develop a prototype in a high-speed processor.

PHASE III: Both stabilization and super resolution have applications in military and civilian applications. The technologies can be used for a variety of military and homeland security applications such as border monitoring, airport security, high value (power plants, chemical plants, water plants, etc.) facility protection, transportation security (subways, trains, highways, bridges, tunnels, etc.), UGV, UAV and Armed Robot applications.

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3) http://cvrr.ucsd.edu/publications/2004/ICPR2004_Junwen_Video.pdf
4) http://www.cad.zju.edu.cn/home/zdjiang/cvpr2003/SuperResolution_CVPR03.pdf

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KEYWORDS: Algorithm, stabilization, super resolution, sensor, multi-spectral, UAV, UGV, Armed Robot

A06-043 TITLE: Automated Target Hand-Off for Future Force Operations

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design, develop and demonstrate the algorithms and software components required to perform automated target handoff for precision cooperative engagement by Future Force LOs, BLOS, and NLOS systems to include use from the individual soldiers to the FCS Unit of Action (UA).

DESCRIPTION: The Future Force will possess a wide range of organic and highly deployable fire support systems that can deliver advanced and fused fires support effects out to operational distances. This capability allows the Future Force to harness a balance of organic direct fires, LOS, BLOS, NLOS, joint and Army fires support capabilities to ensure the success of early entry, forced entry (opposed/unopposed), shaping decisive offense/defense, and SASO operations. The key to success in balancing the Future Force fires and effects resources to achieve victory is the ability to orchestrate and synchronize, in real time, the diverse and versatile mix of fires and integrated effects capabilities, from the individual soldier through the Unit of Action (UA). Automated target handoff from sensors/soldiers through the fires and effects network to appropriate shooters is a major building block in the synchronization of fires and effects. This requires employment of intelligent "assistants," throughout the force, that are able to quickly correlate, and employ, artificial intelligence-based algorithms to compare sensor and other data to historical patterns, perform predictive profiling, and automatically select appropriate fires and effects delivery means to attack targets. It also requires automated selection of the appropriate sensor to shooter links to allow terminal control, observation and reporting of battle damage assessment (BDA), and retargeting. An automated target handoff capability, which reaches from the individual soldier to appropriate LOS, BLOS, and NLOS weapon systems in the UA is desired, such that little or no human intervention is required to determine a) appropriate weapon systems for delivery of fires and effects and b) the communications links for sensor to shooter operations to support delivery of fires and effects.

PHASE I: Investigate innovative artificial intelligence 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 the best overall component design approach and accompanying algorithms for automated target handoff and communications link selection. Demonstrate a proof of principle of the design by showing a mission thread which allows a soldier/sensor to recognize and input a target or target track into a fires and effects network, which then uses agents to perform automated target handoff and communications link selection. Document results.

PHASE II: Develop and demonstrate a prototype component for target handoff and sensor to shooter communications link selection in a realistic, ARDEC-supplied fires and effects architecture. The component must be capable of seamless integration and operation within the ARDEC-supplied architecture, which is component-based. Conduct testing to demonstrate feasibility of the component for all LOS, BLOS, and NLOS, as well as joint weapon systems in a realistic high fidelity simulation environment or actual field environment.

PHASE III: 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.

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KEYWORDS: target handoff, algorithms, sensor to shooter, fires and effects

A06-044 TITLE: Innovative Computer-Aided Manufacturing

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To research and develop new and innovative methods to convert ”G-Code” manufacturing machine language to a Cutter Location (CL) file format that may be imported into various Computer Aided Manufacturing (CAM) software packages allowing manufacturing changes to be made on any CAD/CAM system.

DESCRIPTION: Most Computerized Numerical Control (CNC) manufacturing equipment today uses G-Code machine language created on a CAD/CAM system to automatically machine components. This G-Code can be shared by various manufacturing facilities and run on similar equipment using the same machine control. There are numerous vendors today offering CAD/CAM systems, resulting in most manufacturing facilities having different CAD/CAM systems that are not compatible with each other. If a change needs to be made to the G-Code program, not produced on the facilities CAD/CAM system, the choices are to either totally redo the program, manually edit the program or have the original programming facility make the change. There are many risks that can be involved in doing any of the previous that can result in lost time, scrap or manufacturing equipment damage. The US Army ARDEC’s manufacturing facility has been actively engaged in developing a manufacturing process for Excalibur projectile metal parts using Pro-Engineer software. The Project Manger has expressed concerns about cost and the time required to transfer such a process to any industrial base facility where Pro-Engineer is not used for machine programming. This SBIR effort would allow the manufacturing facility to take the G-Code program created by a different CAM package and run it thru the resulting software package creating a generic CL file. This file would be then further refined to be tailored to individual CAD/CAM software packages allowing anyone to make changes on a G-code program that was made on a different facilities CAD/CAM system. Major Commercial Off-The-Shelf (COTS) CAD/CAM systems will be analyzed and researched to determine the various CL file requirements. Innovative, robust algorithms, translation protocols and user interface will be developed for all major COTS CAD/CAM packages with both complex milling and turning part geometries.

PHASE I: Design and develop new and innovative algorithms and translation protocols for a software package that will demonstrate proof of concept. Demonstrate capability on one simple geometry part provided by ARDEC for one machine (lathe/mill) case study. Verify this system using Pro-Engineer/Pro-Manufacture software.

PHASE II: Develop and refine an innovative computer-aided manufacturing software utility system prototype that can perform translations on multiple major CAD/CAM packages (Mastercam, Unigraphics, Gibbscam and Solidworks/SolidCam) and on several types of equipment (lathe/mill) using a more complex geometry supplied by ARDEC.

PHASE III: For military application, this system can be used for multiple military engineering development projects at all military manufacturing facilities. For commercial application, this system can be used in all major manufacturing facilities such as the automotive and aerospace industries.

REFERENCES:
1) Vericut Simulation Software, Available http://www.vericut.com
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3) Mastercam CadSoftware, Available http://www.mastercam.com
4) Unigraphics CadSoftware, Available http://www.ugs.com

KEYWORDS: CAD, G-Code, Post Processor, Manufacturing, CNC, Computerized Numerical Control, Computer Aided Manufacturing, Machining

A06-045 TITLE: Automatic Target Detection and Recognition Algorithms for Hyperspectral Sensors

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop efficient and fast algorithms for hyperspectral (HS) infrared (IR) imaging sensors that are able to automatically detect and classify targets for future weapon systems.

DESCRIPTION: The objective of this effort is to develop algorithms that are able to automatically discriminate and achieve target recognition capability for future weapon platforms. Smart and precision guided munitions need sensors and algorithms that allow them to detect targets of interest. For these types of munitions, the time frame for processing these image signals is very short. Since hyperspectral sensors accumulate a wealth of information over the IR spectrum, the data obtained from the sensor may be too large to process with today's conventional methods. Hyperspectral sensors have been known to be invaluable to acquire needed information, however algorithm development work in this area is still very new and not sufficiently efficient for Army's applications. The desired algorithm(s) needs to be fast in processing incoming signals for detection and classification of targets ((i.e., ATR (Automatic Target Recognition)). Optimization of such algorithm(s) will include the decision to process all or some of the IR bands captured by the IR-HS sensor. The environment at which these algorithms will be tested and rated will include day/night, all weather/terrain operations, and processing time allocation of raw IR HS data.

PHASE I: Design new methodologies and concepts for IR HS image processing for automatic target detection and classification with the desire of eliminating target look-up tables.

PHASE II: Develop a prototype system based upon optimization of algorithms.

PHASE III: Applications for these algorithms can be found in both the military and civilian life. For the military, sensor fuzed weapons will benefit by being able to automatically recognize and classify targets by prioritization or military value. It can also be used for guidance and control of munitions to a target. For commercial applications, the algorithms can also be used in conjunction with human control systems to provide additional information about the target of interest. Homeland and commercial applications can also include perimeter surveillance and target discrimination (i.e., human from an animal). This type of perimeter surveillance with discriminatory/recognition features built-in very useful for Homeland Defense for border control over a large open area.

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3) Signal Theory Methods in Multispectral Remote Sensing, David Landgrebe.

KEYWORDS: hyperspectral, infrared, IR, sensor, submunition, algorithm

A06-046 TITLE: Novel Plasma Stabilization and Control of Titanium Welding Processes

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a novel, integrated control process for welding titanium for current and future Army systems.

DESCRIPTION: Titanium pulsed gas metal arc welding (GMAW-P) has been the foundation for manufacturing titanium parts to support the Army's current and future system requirements. GMAW-P welding technology has been made available through Army ManTech technology transfer through commercial off-the-shelf welding power supplies. After using this technology in production facilities, it has been noted that arc stabilization technology is required to improve weld performance. At typical GMAW-P travel speeds of 14-24 in/min and arc voltages of 18-22 volts, the arc plasma becomes unstable as a function of welding time. It is believed that this is caused by "un-phasing" of the welding waveform where the electrical signal frequency becomes out of phase to the physical welding conditions (arc voltage, length, and current). In order to obtain welds that are of high quality, it is necessary to develop an adaptive control methodology for novel plasma stabilization control and monitoring of the welding process. This effort proposes the development of an adaptive control/arc monitoring system that will be applied to existing welding hardware. The system will be innovative and beyond the scope of what is currently available commercially. This novel plasma stabilization control/monitoring system will integrate gas quality control with adaptive controls such as vision or other sensors with the goal of adding these to existing commercial welding robotic hardware. The system will allow the user to both monitor welding variables (current, arc length, torch speed, etc.) and make critical changes to these variables during the welding process. Factors effecting gas quality such as oxygen content, hydrogen content and dew point will be researched. Factors such as current, arc length and torch speed will be researched along with the integration of these factors within the system. A relationship between these factors will be outlined and explored. A control methodology integrating these factors using sensors, neural networks, or other concepts will be proposed.

PHASE I: This effort will focus on developing a control algorithm and designing an add-on control hardware that will act in conjunction with the welding power supply to monitor transient conditions and return the arc to equilibrium. Phase I will be used to assess the weld condition and determine a potential algorithm and hardware solution.

PHASE II: Phase II will be used to build a control circuit, the add-on hardware, and to deliver a prototype solution for testing.

PHASE III: In addition to military application in Future Combat Systems, the technology created under this SBIR program is an enabling technology that reduces replacement costs. Potential commercial applications include use in the aerospace and automotive industries.

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http://www.titanium.org/PDF/Newsletters/March2002News.pdf
3) Common gun and torch questions for robotic welding.
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KEYWORDS: Titanium, Welding, Plasma Stabilization, Future Combat System, Robotic

A06-047 TITLE: <u>Innovative Harware-Based Chip Control Technologies</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop an innovative, practical hardware-based approach to eliminate the production of continuous chips during machining operations to increase efficiency, improve worker safety, reduce cost, and accelerate progress toward lean manufacturing.

DESCRIPTION: Machining practice has improved dramatically over the last 20 years. With the advent of new cutting tool technology, better machines, improved computer controls, and advancing skills, machining quality and speed has steadily improved. However, lingering problems remain that hamper the progress toward the lean manufacturing ideal, especially as machining speeds are increased. One of the most prevalent is in regard to chip control. During turning processes, three types of chips are generally produced: fragmented, semi-continuous, or continuous. Fragmented and Semi-continuous chips are easily removed from the machine. Continuous chips, on the other hand, can be disastrous for machining process efficiency and final part quality. Long, continuous chips are difficult to evacuated from the machining zone. Often the production of such chips causes a long entanglement of chip material in the vicinity of the cutting edge. This collection of continuous chip material must be removed by an operator using a hand tool after stopping the machining process. Not only is the interruption of the process an significant loss in efficiency, the removal of the sharp chip material represents a safety hazard for the operator. Over the years, cutting tools have included surface features for chip control [1] and detailed analytical models have been developed that describe chip mechanics [2]. However, they cannot address the full range of processing conditions expected during real-world manufacturing operations. Hence, this information is often useless to the machine tool operator or the manufacturing engineer. Advanced computer simulations of the machining process are available that provide information on chip segmentation and break-up. However, the cost and time investments required for these simulations preclude their use as a practical method to address chip control on the shop floor. New, practical, hardware-based approaches are needed to address the problem of chip control to increase efficiency.

PHASE I: Design an innovative hardware-based chip control system. Validate the systems performance by running a number of mutually agreed upon test cuts of varying speeds, feeds, depths of cuts and materials. Document and analyze results.

PHASE II: Develop a prototype of the validated system. Integrate the resulting system into a CNC-based turning tool. Demonstrate the systems performance in a “real-world, well documented” manufacturing operation provided by ARDEC. Document results and measure performance by comparing data to present operating conditions. Analyze the data to determine if increased efficiency can be obtained resulting in lower production times and cost savings due to the formation of fragmented or semi continuous chips. Run testing to determine if increased speeds and feeds can also be obtained as well as increased tool life resulting in cost reductions.

PHASE III: The system can be used for both military and commercial applications by teaming with end-users, machine tool makers, and metal working tool manufacturers. For military applications, the development of chip control technologies for lathe turning operations can be readily applied to manufacturing future weapon systems. For commercial applications, the development of chip control technologies can be applied to milling operations and other private sector applications. The prevalence of machining operations in the United States offers opportunities to scale the innovation to suit a variety of markets.

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KEYWORDS: chip control, machining operations, lathe turning, CNC (Computer-Numerically-Controlled)

A06-048 TITLE: <u>Innovative Polarized RF Reference Sources</u>

TECHNOLOGY AREAS: Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop an innovative adaptive polarized RF reference source for establishing a battlefield position and orientation referencing system. Such a referencing source is intended to be used onboard weapons platforms, munitions, UAVs, and handheld devices to determine position and orientation relative to the established referencing system using a variety of RF sensors such as those based on cross-polarization, surface antenna arrays, etc. The proposed concept must be easy to deploy and must provide a reliable and secure reference source as an alternative to

GPS, lasers, magnetometer and inertia technologies for the next generation of smart munitions and weapon platforms. Methods to illuminate radio frequency sensors and/or arrays of sensors need to be developed for guided munitions to provide positioning and range alternative solutions to play a role in the guidance, control and layered navigation approaches. A mortar application should be considered as a prototype, followed by application of novel concepts in a small and medium caliber application.

DESCRIPTION: It has been shown that polarized RF sources can be used to establish position and orientation referencing systems over an entire battlefield. The sources may be fixed or mobile, on the ground or in the air. The establishment of such a position and orientation referencing system is highly advantageous since they can enable smart munitions, weapon platforms, vehicles and warfighter to have a common accurate, reliable and secure position as well as orientation referencing system. Such a referencing system will also allow smart munitions and weapon platforms to be equipped with low volume, lightweight, low power, inherently hardened and relatively low-cost onboard position and orientation sensors that provide position and orientation relative to this referencing system. Such referencing systems have also the potential of being used by the command and control, forward observers, UAV, and warfighters alike. As a result, errors due to cross-referencing, loss of GPS signal, inherent errors in inertia devices and rate gyros, are significantly reduced and the effectiveness of munitions guidance and control systems will be greatly improved. The proposed sources must be relatively small and low power, rugged, and should be adaptive, i.e., be capable of being deployed very quickly without the need for calibration and/or adjustments. The proposals should address the issues of position and orientation measurement accuracy with the proposed referencing system, sensitivity, susceptibility to environmental noise and methods of reducing their effects, and in and out of line-of-sight issues. The RF frequencies of interest are in the 8-100 GHz range. The proposals must address issues related to reducing the probability of detection of the reference sources and methods of establishing an absolute referencing system.

PHASE I: Design an innovative adaptive polarized RF source to be used to establish full position and angular orientation referencing systems in the battlefield. The sources must adapt to a known plane of reference using simple and rugged mechanisms.

PHASE II: Develop analytical models to simulate the performance of the proposed RF sources. Develop and fabricate a prototype of the proposed adaptive polarized RF source and demonstrate its performance and precision in controlled field tests.

PHASE III: The development adaptive RF sources for full position and orientation referencing has a wide range of military, homeland security and commercial applications. In the military related areas, the developed position and orientation referencing system enable smart munitions, weapon platforms, vehicles and warfighter to have a common accurate, reliable and secure position as well as orientation referencing system. The referencing system can then be used for guidance and control of all smart munitions, missiles and guided bombs as well ground and airborne weapon platforms with minimal error due to the use of a single position and orientation referencing system. The developed position and orientation referencing system also has military, homeland security and commercial applications for guidance and control systems of various, robotic systems, particularly those used for remote operation in hazardous environments, which may be encountered in homeland defense, and for almost all mobile robotic applications used in the industry for materials handling and other similar applications. Commercial applications also include material handling equipment such as cranes; loading equipment, particularly in the sea; and industrial equipment used in assembly, welding, inspection, and other similar operations.

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KEYWORDS: RF Sources, Polarized RF Sources, RF Sensors, Position and Orientation Referencing, Guided Munitions, Smart Munitions, Guidance and Control

A06-049 TITLE: Novel Miniature Inertial Igniters for Thermal Batteries

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop novel inertia based miniature igniters for thermal batteries for gun fired munitions that could be scaled to thermal batteries of various sizes and shapes. The objective is to develop innovative miniaturized ignition mechanisms as well as related pyrotechnics, while increasing safety related to accidental ignition during handling and in case of dropping.

DESCRIPTION: In recent years, new improved chemistries and manufacturing processes have been developed that promise the development of lower cost and higher performance thermal batteries that could be produced in various shapes and sizes, including their small and miniaturized versions. Such thermal batteries could be ignited electrically or by inertia forces generated due to the firing acceleration. The function of igniters in thermal batteries is to provide a controlled pyrotechnic reaction to produce output gas, flame or hot particles to ignite the heating elements of the thermal battery. Electrical ignition, however, requires electrical energy, thereby requiring onboard battery or other power sources with related shelf life and/or complexity and volume requirements. The primary objective of this SBIR project is the development of novel inertial igniters for thermal batteries used in gun fired munitions, particularly small and low power thermal batteries for use in fuzing, thereby eliminating the need for external power sources. The proposals should including the development of novel inertia-based ignition mechanism concepts and their related pyrotechnics. The proposed innovative inertial igniters are preferably scalable to thermal batteries of various sizes, with particular interest to miniaturized igniters for small size thermal batteries. The proposed igniters must be safe and do not initiate if dropped from 7 feet on concrete floor, should withstand firing accelerations of up to 50,000 Gs; and ignite at 1000 Gs and 5 msec. The proposal must also consider the cost manufacturing.

PHASE I: Design novel inertia based miniature igniter concepts for thermal batteries, particularly for use in small and low power thermal batteries. Develop analytical models of the dynamics of the inertial mechanisms of the proposed igniter concepts for determining the feasibility of each developed concept and simulate its performance under various firing and accidental drops conditions and for optimal selection of their various design parameters. Address issues related to the pyrotechnics.

PHASE II: For a selected thermal battery for a low power fuzing application, develop proof-of-concept prototype for the best developed igniter concept.

PHASE III: The development of miniature inertia based igniters for thermal batteries that are cost effective is essential for the development of low cost, safe, small and low power thermal batteries, particularly for fuzing applications. The developed inertial igniters will also have a wide range of dual use commercial, as well as other military applications. On the military side, the igniters could be used on a wide range of munitions to reduce cost and increase safety. 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: igniters, thermal batteries, pyrotechnics

A06-050 TITLE: Novel Actuators for Active Aerodynamic Control of Gun Fired Munitions

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a novel actuator for active flow control for use in the US ARMY’s current projectile systems that would decrease dispersion and enhance maneuverability.

DESCRIPTION: Novel actuators for active flow control have the potential to improve the efficiency and accuracy of US ARMY projectile systems by modifying both the internal and external aerodynamics. The primary driver for novel actuators is the expectation that the flow control will result in significant aerodynamic performance benefits at the system level when all trade-offs are factored in. Successful application to US ARMY airborne systems can produce lighter, stealthier, more agile projectiles with increased range, and payload accuracy. The design of a novel actuator such as a plasma actuator or a micro-flap actuator for active flow control system requires knowledge of the flow phenomena and selection of appropriate actuators, sensors, and control algorithms. The objective of this SBIR announcement is to seek the development of an innovative actuator concept as part of the flow control loop.

Active flow control techniques can be separated into two classes based on flow physics. The first class (low frequency excitation), involves the use of unsteady forcing by the actuator to excite instability waves in laminar flows, or in the large scale structures of turbulent flows. The second class (high frequency excitation), has been developed more recently. It involves the use of actuators to force the turbulent boundary and free-shear layers at high frequencies in the dissipative range. The actuator is an important element of the flow control loop. It is used to inject prescribed perturbations into the flow. New actuator concepts, therefore, are needed that cover both the low and high frequency excitation range in order to be useful for the full range of aerodynamic conditions experienced during the entire flight of the projectile. By the nature of the aerodynamic vehicle under consideration, actuators should be non-intrusive with minimal moving parts and should operate without mass injection and with a high degree of control authority without compromising the dynamic range. These actuators should also be dynamically controllable with low response times and easily integrated into the weapon delivery system. They should also be low cost and insensitive to outside conditions such as temperature and EMF fields.

PHASE I: Design novel actuator for active flow control.

PHASE II: Develop and demonstrate a prototype projectile with a novel actuator for active flow control in a high-G environment such as an air/rail gun. Demonstrate concept feasibility by firing from standard US ARMY projectile. Demonstrate novel actuator performance and flight dynamics.

PHASE III: Concept can be utilized by services such as the Air Force, Navy and Marines as well as in commercial air vehicles.

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KEYWORDS: Novel, plasma, actuator, control, active flow control (AFC), projectile, and stealthier, micro-flap

A06-051 TITLE: Infrared Hyperspectral Linear Array Sensor

TECHNOLOGY AREAS: Electronics, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To develop a new, rugged, low cost, low power, and preferably uncooled hyperspectral infrared sensor that can be implemented into munitions in order to detect targets more effectively.

DESCRIPTION: Sensor fuzed and precision guided weapons in the future need sensors that allow for a multitude of information to be captured for target recognition capability. To afford this capability, it is important to develop sensors that can acquire a large amount of information in its field of view (FOV) for target detection and characterization. It is imperative that tomorrow's munitions have sensors that can help accomplish automated target recognition effectively. In addition, this sensor must be capable of being miniaturized, hardened for gun launch survivability and meet minimal power demands that are required for munition applications. With this in mind, the primary objective of this SBIR project is the development of a new infrared hyperspectral linear array camera that allows for information to be simultaneously collected in the 3-5 micron and 8 – 14 IR ranges that meets the aforementioned application needs. The system is expected to work in all type of terrain and weather environments and in day and night situations. The intended purpose is for enhanced imaging and discrimination ability. Ultimately these enhancements are expected to yield a high degree of Automatic Target Recognition (ATR) capability.

PHASE I: Design innovative hyperspectral sensors and related components that allow for detection of object of interest in the 3-5 micron and 8 – 14 IR ranges. Develop concepts, models, and simulations to determine the efficiency and effectiveness of such system. Illustrate the feasibility, advantages, and disadvantages of such concepts. Optimize preliminary designs for use in a G-hardened environment, with well thought-out plans and analyses for future miniaturization and minimization of power consumption of such sensors.

PHASE II: Demonstrate a prototype of the proposed system.

PHASE III: The development of a dual band IR hyperspectral sensor has a multitude of applications for both military and civilian world. For example, such a miniaturized hyperspectral sensor can be used very effectively in a multitude of DoD munitions and Homeland Defense applications. Infrared applications are in use today in submunitions and missiles applications for target detection, targeting, and guidance and control situations. Other applications include area surveillance for target detection and fire control applications used in munitions and military vehicles. Such miniaturized systems can also be easily and readily relocated into the commercial world. IR cameras are an integral part of any surveillance system and the need for miniaturized systems that are able to detect targets of interest.

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KEYWORDS: Hyperspectral, Infrared, IR, sensor, submunition

A06-052 TITLE: Collaborative Engagement with Unmanned Systems

TECHNOLOGY AREAS: Information Systems, Battlespace, Weapons

OBJECTIVE: Design, develop and demonstrate the algorithms and software components required to perform autonomous collaboration between 2 or more unmanned systems (UMS) (both air and ground) in order to achieve collaborative engagement of targets with Line of Sight (LOS) and Beyond Line of Sight (BLOS) fires, given appropriate operator approval of target engagement.

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 collaboration on target engagement would take place autonomously between UMS, with final decision on target engagement being left to the human operator. This implies 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, as should both lethal and non-lethal engagement means. The collaborative engagement capability should be developed as a software component or components capable of insertion into multiple software architectures, and capable of use in multiple operating systems, to include real time operating systems.

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, ARDEC-supplied fires and effects architecture. The component must be capable of seamless integration and operation within the ARDEC-supplied architecture, which is component-based. Conduct testing to demonstrate feasibility of the component for operation within a simulation environment, and with actual UMS currently operated by ARDEC.

PHASE III: 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

A06-053 TITLE: GPS Denied Guided Gun Fired Smart Munitions

TECHNOLOGY AREAS: Electronics, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a concept for an Advanced Guidance, Navigation, and Control system that performs and maintains precision kill capability during environments where the Global Positioning System (GPS) is temporarily unavailable.

DESCRIPTION: Hardened Inertial Measurement Units (IMUs) suitable for gun projectiles require continual GPS aiding to achieve precision kill capability. The incorporation of new and innovative aiding schemes reduce errors in the Guidance, Navigation and Fuzing functions leading to a robust kill probability during GPS denial scenarios. New coupling of GPS aiding with current gun hardened inertial sensors, addition of new sensor types, such as but not limited to, magnetic phenomena and the addition of nonlinear neural net and/or fuzzy logic processing schemes have potential to improve projectile kill probability during GPS outages.

The desired goals are miniaturization to fit within the 155mm and 105mm fuze-well restrictions; plus performance values improving the inertial solution to effectively tactical grade capability, gyro drift (~1 deg/hr), angular random walk (~0.1 deg/rt-hr) with accelerometer drift (~.3 mg) and accelerometer noise(~100 µg/vHz) through completion of the mission and including GPS outages post-apogee. These innovative aiding techniques must be able to withstand high shock (20,000 g's) gun launch environment and successfully calibrate/recalibrate after gun launch. The technologies proposed should not be confused by the presence of jamming, other Electro-magnetic Interferences and/or be degraded during prolonged storage.

PHASE I: Design a guidance control and navigation technique that can augment a GPS-aided guidance system by providing GPS like guidance in the absence of GPS' availability and can enhance the performance of a GPS guided weapon when GPS is available. Identify the proposed technology and conduct analytical efforts to demonstrate technology capability.

PHASE II: Develop a prototype system of the proposed technology in a laboratory environment and demonstrate feasibility of results by means of a field test. The goal is to demonstrate the proposed concept on a guided munition that currently uses the Global positioning System (GPS) signals in conjunction with inertia measurement units to provide feedback guidance signals to correct the path of a munition or an object in motion. Demonstrate that if GPS is jammed for increasing periods of time, the guided munition would maintain the required precision.

PHASE III: The development of methods that augment GPS-aided guidance will have a wide range of military, special forces, homeland security and commercial applications. In the military related areas, this development will be demonstrated for the guidance control and navigation of precision smart munitions in areas where GPS is jammed or turned off temporarily. In particular for special forces applications in urban areas where GPS reception may be difficult to maintain. In military applications, the integration into advanced projectile based munitions for demonstration of system capability would be completed by technology infusion into either the prime contractors or their component suppliers for the current developmental programs. The form of the technology would be structured so as to be capable of adapting to both fielded and developmental programs. Additionally the technology would be applicable to both Army and Navy gun systems, allowing mutually economical benefits based on required quantities. The demonstrations also have the potential for significant contributions in homeland security and commercial applications, in particular for applications for the guidance, control and navigation of UAVs and robotic platforms for dangerous applications, and other commercial applications of robotics and automation

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KEYWORDS: augmented GPS, guidance and control, navigation, gun-fired survivability

A06-054 TITLE: Advanced Processing Techniques for Novel High Strength Magnesium Alloys

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop novel mggnesium composites to reduce the weight of the Army's Lightweight Mortar and other relevant systems.

DESCRIPTION: The Army is in the process of reducing the weight of existing systems and creating new lightweight systems. In order to accomplish this goal it is necessary to explore the use of innovative materials and application processes. This SBIR looks at the constant problem of system weight reduction. Magnesium Alloys have been proven to have desired light weight and density characteristics for numerous military applications. Magnesium has been overlooked in the past partly because of problems with corrosion and the generally accepted use of Aluminum. The current challenge for the Army is to make a leap forward in terms of lightweight systems. Dismounted mortar systems and small arms systems have reached weight/functionality limits with Aluminum. The next step forward requires the development of Novel Magnesium Alloys along with novel techniques to form, cast and weld the Magnesium Alloys. Magnesium weighs 1/3 less than Aluminum. New technology has made it possible to prevent or greatly reduce the corrosion of Magnesium. Magnesium has the lowest density of engineering metals. This SBIR will explore the use of Magnesium Composites in the development of components for the Lightweight Mortar and/or small caliber weapon weight reduction efforts.

PHASE I: Design a process using novel Magnesium Composites to form a pre-selected component for the Lightweight Mortar or a small caliber weapon. Investigate existing processing techniques used for Magnesium Composites. Study existing methods to reduce/eliminate corrosion problems associated with Magnesium. A trade off analysis will be conducted to compare the potential potential Magnesium Alloy components to existing components.

PHASE II: Manufacture prototype component for the Lightweight Mortar or a small caliber weapon. Subject the component to appropriate metallurgical evaluation. Evaluate the component based on the selected evaluation criteria. Explore other items that may be fabricated using Magnesium Composites.

PHASE III: Potential commercial applications include the production of novel High Strength Magnesium Alloy parts/components for numerous military systems. It will be possible to expand the fabrication process to develop novel High Strength Magnesium Alloys parts that can be used by private defense contractors, aerospace industries and automotive industries.

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http://www.fas.org/man/dod-101/sys/land/m224.htm
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KEYWORDS: Magnesium, Novel, Corrosion, Weight Reduction, Mortar

A06-055 TITLE: High Temperature Sensor for Consolidation of Refractory Metals and Alloys

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a high temperature, real time (up to 1650C) sensor to monitor and optimize consolidation of refractory metal and alloy powders into fully dense bulk material with the desired microstructure.

DESCRIPTION: High temperature eddy current sensors have been successfully used to monitor in real-time and optimize the consolidation of temperature sensitive materials, such as structural amorphous powders. The critical temperature for this application was up to 650oC. These sensors were further used to characterize the densification behavior of powder blends consisting of amorphous powder and tungsten powder. In this application, the sensor measurement was used to identify the maximum temperature required to achieve full density for the bulk composite while preventing the formation of the brittle intermetallic layer along the amorphous powder/tungsten powder interface. The critical temperature for this application was up to 1200oC. A current unsolved challenge is the consolidation of nanostructured refractory metal powders, which require a maximum temperature above 1200oC. The exposure of nanocrystalline materials to high temperature during consolidation will result in excessive grain growth and the loss of the nanocrystalline structure in the fully dense bulk material. A high temperature sensor is required to measure the densification rate in real-time, and identify the maximum temperature required to achieve full densification in order to minimize grain growth and obtain a fully dense bulk material with a nanocrystalline structure. The absence of a high temperature sensor will require a trial and error approach with a great number of experiments and a large amount of powder, which may be in short supply. A sensor will reduce the need for powder and will help to fully characterize the densification behavior of this class of materials. The U.S. Army is seeking a high temperature, non-contact sensor to monitor powder consolidation in real-time up to a temperature of 1650oC. The new sensor can be based on eddy current technology or any other innovative technology that would serve the purpose.

PHASE I: Design an innovative non-contact sensor for monitoring the consolidation of a refractory powder, such as tungsten, in real-time and up to a temperature of 1650o C. Demonstrate the feasibility of the design by testing the candidate materials selected for the sensor and identifying the maximum temperature and pressure that the sensor can withstand with acceptable thermo-mechanical stresses.

PHASE II: Develop and build a prototype, high temperature real time sensor. Demonstrate the sensor by real time measurement of the densification of a refractory powder, such as tungsten, into a fully dense bulk material with the desired microstructure.

PHASE III: For military applications, the sensor can be used for future weapon systems; for commercial applications, it can be used for processing thermal management materials for semi-conductor products, wireless communication and internet infrastructure, and for refractory metals and alloys for metal working, mining, highway and construction industries.

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KEYWORDS: high temperature sensor, tungsten powder, powder consolidation, bulk nanocrystalline tungsten, nano powder

A06-056 TITLE: Innovative Predictive Model for Determining Bore Erosion

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a creative and innovative predictive model for determining bore erosion life of current and proposed Future Combat System (FCS) concepts and associated firing scenarios. This SBIR effort must provide innovative research concepts and designs that bridge predictive bore erosion life modeling gaps for FCS. This effort must address current and proposed concepts and mixed firing scenario (rounds, charges, projectiles, conditioning temperatures, firing rates) combinations.

DESCRIPTION: The development of a predictive erosion model for large and medium caliber gun systems has made great strides since its onset in the early 1990's for traditional gun systems. The Reference Section below chronicles work leading to the current state-of-the-art of predictive erosion models for traditional large-and-medium-caliber gun systems that leveraged over forty years of rocket erosion modeling. FCS differ from traditional gun systems in a number of ways. They include a group of lighter gun systems with the lethality of the current heavier gun systems. Engineering challenges for the FCS include the incorporation of higher-strength gun-steels, higher-performance bore coatings, lightweight insulating composites, thinner-walled/lower-heat-sink gun tubes, high-performance charges/charge additives, and high-performance/higher-rate-of-fire projectiles. Current off-the-shelf thermo-chemistry, transient computational fluid dynamic boundary layer, heat transfer, and gas-wall degradation modeling technology does not satisfy the bore erosion life modeling gaps for Future Combat Systems. These gaps include: [1] multi-component bore-wall-materials, [2] mass-addition from combustible cases, additives, multi-layer propellants, and deterred propellants, [3] turbulent heating at surfaces, cracks and pits, [4] gas-wall thermo-chemical kinetics/degradation and associated catalytic effects, [5] platelet-substrate adhesive strength versus interface degradation, and [6] multi-directional venting. (A platelet is a small coating element). The Army needs innovative research concepts and designs that address these six modeling gaps for determining bore erosion life of current and proposed FCS. Over the last ten years, program managers have used calibrated bore erosion life predictions to supplement the scarce funding for live-fire erosion life testing. The cost of these erosion life predictions was a very small percentage of live-fire testing and live-fire testing later confirmed many of these predictions. FCS program managers have similar predictive erosion life modeling requirements.

PHASE I: Provide innovative research concepts and designs that bridge predictive bore erosion life modeling gaps for the operating regimes of FCS as mentioned above. The resulting research effort must have sufficient scope and growth potential to support current and proposed FCS concepts and mixed firing scenario (rounds, charges, projectiles, conditioning temperatures, firing rates) combinations. Current off-the-shelf thermo-chemistry, transient computational fluid dynamic boundary layer, heat transfer, and gas-wall degradation modeling technology does not satisfy the bore erosion life modeling gaps for FCS.

PHASE II: Develop these innovative research concepts and designs into a predictive and user-friendly thermal-chemical-mechanical prototype erosion life model incorporating the six indicated FCS modeling gaps. This predictive prototype model must be able to incorporate input data from system configurations, firing scenarios, instrumented firings, bore inspections, and bore characterizations. Other deliverables will include associated model executables, source code, and manuals.

PHASE III: There are numerous direct commercial and government dual-use applications for the erosion code developed in this SBIR effort. Advanced transient and steady-state erosion modeling in high temperature, high pressure, high velocity, and high-performance H-C-O-N combustion systems is in high demand. This modeling can provide solutions to wall materials degradation, damaging combustion products, non-optimized combustion chamber geometry, etc. The erosion code developed in the SBIR benefits commercial and government laboratories that analyze, design, and evaluate gun systems, rocket systems, internal combustion engines, and jet engines. Transient combustion occurs in gun systems, pulse-detonation rocket engine cylinders, internal combustion engine cylinders, and rapidly accelerating/decelerating high-performance jet engines.

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KEYWORDS: Gun Systems, Predictive Models, Bore Degradation, Bore Erosion, Computational Fluid Dynamics, Thermal, Thermo-chemical, Thermo-mechanical

A06-057 TITLE: High Efficiency Quantum Dot Based Photo Voltaics

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a photovoltaic solar cell that utilizes quantum dots, has low weight, low cost, and high conversion efficiency.

DESCRIPTION: Soldiers and mechanized forces of the future will need portable, lightweight renewable energy sources during deployment in order to power elements of the Future Combat System such as Unmanned Aerial Vehicles (UAV), Unattended Ground Sensors, Intelligent Munition Systems and the Soldier without the use of heavy, short lived-batteries. Photovoltaics are an abundant, clean, quiet, renewable source of power that can be used in military applications as a source of stand alone power or to recharge batteries that could be used during low-light hours. High material costs and low efficiency of traditional silicon photovoltaic materials has limited their use thus far. Research into new Quantum Dot (QD) semiconductor nanocrystal materials has shown that quantum yield (electrons produced per incident photon) could increase to 300% due to a quantum effect called multiple exciton generation. Technical advances have enabled the manufacture and band gap tuning of quantum dot nanocrystals to access a broader range of the solar spectrum, maximizing solar energy potential with low cost and high efficiency. Lightweight and flexible conjugated polymer based solar cells currently suffer from low efficiency but could greatly increase with QD technology.

PHASE I: Establish feasibility of concepts for a quantum dot based solar cell that can effectively absorb the solar spectrum and transport photogenerated electrons out of the QD for useful electricity. Identify a path to study the dispersion and concentration effects of the QD in a flexible, light weight material that has a conversion efficiency of (>5%), with a goal of 15-30% or higher, and a cost goal approaching $1/watt.

PHASE II: Develop and deliver a prototype system that effectively uses quantum dots in a material that is resistant to environmental and operational degradation for long lifetimes (>10,000 hrs use) and is both highly efficient (conversion efficiency goal of 15-30%) and has a cost that approaches $1/watt or less.

PHASE III: These materials and systems would have widespread use in the commercial market wherever solar cells are used and wherever their use was avoided previously because of low power and high costs. Highly efficient, low cost photovoltaics could be used from consumer electronics to power grids. The military could incorporate them into applications where the power requirements could be met by these materials such as UAV's, unmanned robots, sensors and armaments, and soldier equipment.

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KEYWORDS: quantum dots, semiconductor nanocrystals, photovoltaics, solar energy

A06-058 TITLE: <u>Synthesis of Nano Composite Super Thermites with Tunable Energy Release</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Exo-Atmospheric Product Office, MDA, Joint Program Office

OBJECTIVE: Develop a synthesis method for the production of self-assembling fuel nanoparticles around metal oxide nanorods or nanowells with dispersed chemicals.

DESCRIPTION: Nanoscale thermites have shown to have superior performance characteristics over conventional, micron-sized bulk composites as evidenced by their enhanced burn rates and energy releases. This utility will be enhanced through the development of a process with which the material's desired properties, energy release, burn rate, pressure, and burn rate temperature, can be “tuned” to meet various operational requirements as green primers, or additives to propellants and explosives.

PHASE I: Perfect current methods and develop novel methods to produce gram-quantities of various targeted nanocomposites. Demonstrate proof of concept of the superiority of these materials through performance tests, such as burn rate measurement, pressure and temperature measurements, shockwave velocity. Confirm efficacy of use through sensitivity testing. Correlate processing conditions to performance and sensitivity characteristics in order to enhance control of the “tunable” nature of the material.

PHASE II: Scale up the process beyond pound-quantities of material. Establish standard operating procedures for larger operations in terms of both safety and the production of final products. The correlation initially conceived in Phase I shall be optimized as the effort moves from gram-quantities to higher outputs. The material shall be tested within specific systems and reaction control studies will be performed to provide further understanding of the unique materials developed under the program.

PHASE III: In addition to superthermite materials’ use as green primers and in propellants and explosives, many offshoots can be generated from both the process, the material, and the components of the material. For example: Copper oxide, one of the materials currently being studied, can also be used as a fungicide and as a catalyst for certain systems. Optimizing and scaling up production of the material will offer an alternative, and superior, source to firms and consumers who use products based on materials such as this. The flexibility of the process and the lessons learned from the study will allow researchers to transfer this technology over to other industries so that other materials, such as pharmaceuticals, can be produced in a similar fashion. This will allow for a level of optimization and control of particle size and quality that current technologies.

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KEYWORDS: thermite, superthermite, metastable intermolecular compound, metal oxide, self-assembly

A06-059 TITLE: Virtual Demonstrations for Infantry Training

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a system to rapidly generate Virtual Environment instructional demonstrations for training small teams to conduct urban and asymmetric warfare operations.

DESCRIPTION: One of the greatest training challenges today is to prepare small units (an infantry squad, for example) for asymmetric warfare operations and Military Operations in Urban Terrain (MOUT). Virtual Environment (VE) training systems, such as the Virtual-Integrated MOUT Training System (V-IMTS), have been developed to provide flexible and cost effective complements to live training systems. These VE systems are not envisioned as replacements for live training, rather they are to be components of an integrated, comprehensive training program using live and constructive training resources, as well as the virtual training systems.

For small teams preparing for MOUT operations, VE systems, using trainee controlled avatars and computer generated entities, are well suited for providing extensive and flexible practice with performance feedback. VE systems can currently provide the capabilities to view mission exercises from any angle, and to view clearly team actions inside of buildings. These viewing options are also available during After Action Review replays, with additional capabilities for controlling the chronology and speed of the replay. In addition, VE systems highlight the display of mission-critical salient cues, and can record and present in precise detail the state and activities of individuals, such as their posture and field of view.

These same VE system capabilities that enable the creation, conduct, and replay of MOUT training exercises could conceivably be used to generate and present Virtual Environment instructional demonstrations (see Lampton, McDonald, Rodriquez, Morris, and Parsons, 2001). These demonstrations would provide examples of the proper conduct of team tasks and could also support "what if" analyses of alternate courses of action. They could also support mission rehearsal applications.

Military training doctrine has long recognized the instructional strategy value of demonstrations: "Demonstration is the preferred method of presentation used at company level and below. Demonstrations accelerate the learning process. The impact of a brief visual demonstration showing the correct method of execution of a given task to standard cannot be overstated. Seeing a task performed correctly provides greater understanding than any amount of explanation. Demonstrations stimulate soldier interest by providing realism that other techniques do not offer. Demonstrations save time by showing Soldiers the correct way to perform a task". (Field Manual No. 7-1).

In the past, the demonstration technique has been more suitable for individual rather than team tasks. However, recent developments in VE training systems provide the opportunity to combine the highly effective traditional instructional strategy of demonstration with the unique capabilities of VE systems to rapidly generate replayable records of small team mission exercises. These VE demonstrations could be part of a program to support the training of: Unit Standard Operating Procedures; Rules of Engagement; specific Tactics, Techniques, and Procedures; general concepts of tempo of team actions; and effective communications in the context of an ongoing mission.

Demonstrations would also be useful prior to training by multinational forces who have not previously trained together. The recorded demonstrations could be presented via: PDAs, online standard PCs, DVD players, or existing After Action Review theaters.

Finally, demonstrations could be used to quickly disseminate information about new tactics, developed for friendly forces or used by opposing forces. Conceivably, a VE demonstration could be ready for distribution within 24 hours of the receipt of a description of the new tactic.

The military is moving to common standards in simulation systems. Technical, engineering, and architectural guidance and standards will facilitate interoperable and integrated simulation, training, and instrumentation capabilities. The proposed topic solution should demonstrate awareness of relevant standards. The proposal should provide an explanation of how the proposed solution is consistent with those standards, or provide a clear rationale for alternative approaches. The proposed approach must ultimately lead to a fieldable, supportable product.

Current DoD-adopted standards for distributed simulations are the High Level Architecture (HLA) and the Distributed Interactive Simulation (DIS) (information is available at http://www.dsp.dla.mil/ or http://www.assistdocs.com/).

Other general areas of standardization (examples are listed) include:

Architectures/Frameworks: OneSAF (Semi-Automated Forces) Product Line Architecture Framework, Virtual Simulation Architecture (VSA)
Components: OneSAF SAF Product and supporting Components, SNE (Synthetic Natural Environment) Virtual Data Repository (SVDR)
Standards: Synthetic Environment Data Representation and Interchange Specification (SEDRIS) (http://www.sedris.org/), Objective Terrain Format (OTF)
Interfaces/Data Interchange Formats: Military Scenario Definition Language (MSDL), MILES Communication Code (MCC) Data Models: Command & Control Information Exchange Data Model (C2IEDM) http://www.mip-site.org/, OneSAF Objective System (OOS) Environmental Data Model (EDM) Processes/Guidelines: GUI Style guide

PHASE I: Conduct a review of previous research to identify the training settings and types of individual and team tasks for which instructional demonstrations are likely to be most effective. Compare these with current and anticipated Army training challenges. Identify general categories and provide some specific examples of individual tasks, and team tasks and missions, that could be trained more effectively with the use of demonstrations. Survey relevant subject matter areas for information on content, format, and presentation of effective demonstrations. Synthesize the results to develop guidelines for their use and identify unresolved critical issues. Develop an initial theory for the instructional strategy of demonstration. Survey relevant technologies for creating, distributing, and displaying demonstrations. Outline the economic feasibility of a demonstration system including consideration of manpower, personnel, and system training issues. Phase I research should document the feasibility of the concept of enhancing the effectiveness of training for small teams for urban and asymmetric warfare operations by the use of Virtual Environment instructional demonstrations.

PHASE II: Develop an initial working prototype to permit empirical investigation of the critical issues identified in Phase I. This research should result in incremental improvements to the prototype system. Phase II activities should include the development and documentation of a sound theoretical basis for the instructional strategy of demonstration. Critical research issues will be identified in Phase I, but potentially include issues such as when, if ever, a demonstration should depict incorrect team performance (for example, depict a common team error and the resulting negative outcome), and identification of any unique requirements for training distributed teams. Consideration should be given to how demonstration fits into an integrated approach of giving guidance before, during, and after task practice. The Phase II effort should produce complete guidelines for the design, production, distribution, and use of demonstrations; and any hardware and software required for their development.

PHASE III DUAL-USE COMMERCIALIZATION: Potential commercial markets include law enforcement, emergency responders, transportation and industrial safety training, and team sports applications.

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http://www.hqda.army.mil/ari/pdf/tr1110.pdf

KEYWORDS: Infantry, training, Virtual Environments, instructional strategies, demonstration, team training

A06-060 TITLE: Team Composition Optimization Tools

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop computational algorithms and tools for commanders to optimize the allocation of personnel to mission and staff teams in order to maximize overall unit effectiveness across all missions.

DESCRIPTION: The diversity and intensiveness of U.S. missions has severely increased the demands placed on units, and consequently on leaders to manage their accomplishment. To the extent that commanders have some discretion in the assignment of personnel to missions, maximization of overall unit effectiveness will depend largely on the commander's ability to optimally assign personnel to specific missions. This optimization of personnel utilization will depend on the commanders understanding of task requirements, individual capabilities, and the team capabilities created from different combinations of individuals assigned to a team.

Current behavioral science research has begun the exploration of how different combinations of individuals, and their capabilities, result in varying sets of team capabilities and examined the resulting impact on team effectiveness. Individual characteristics, including personality and cognitive abilities, have been examined in their contributions to team effectiveness. However, there remains a significant gap between the current state of research and the point at which technology development can arise from the accumulated body of knowledge. Mathematical models hold promise for accelerating the research in this area and development of technologically feasible approaches to enhancing team staffing decisions.

The objective of this topic is to close this gap significantly, and produce prototype algorithms and tools for use by commanders to maximize unit effectiveness across all assigned missions. These prototype algorithms and tools will incorporate extant knowledge on team composition (e.g., complimentary fit, separation diversity) as well as identifying new methods for considering the placement of individuals into teams. Additionally, the approach taken should account for both individual performance for team members as well as team performance as a whole.

PHASE I: Phase I will produce a demonstrated methodology for identifying useful algorithms for the allocation of personnel to mission teams in order to optimize effectiveness across all missions simultaneously and should specifically consider individual capabilities, history of performance, and potential synergy between individuals. Mission tasks should include a variety of domains including planning, decision making, social task performance, and physical task performance. This methodology should be proven through empirical demonstration. Phase I will also produce a storyboard prototype of the tool for commanders' use, and include a detailed description of how commanders will be able to utilize the tool during deployed operations. The prototype tool should be designed to sustain a short learning curve for users. The prototype tool should enable commanders to analyze mission tasks and demonstrate basic capability for exploring different combinations of personnel. If the prototype tool is designed to access or house personnel information, security measures preventing unauthorized access to this information shall be clearly identified and demonstrated.

PHASE II: Phase II will produce a fully functional prototype tool incorporating the developed algorithms for allocation of personnel. Algorithms will be tested against data from actual teams, although these teams may be composed of non-DOD personnel if necessary. It is expected that personnel data, as well as other data required by the tool not currently collected or stored within the Army personnel systems, will be collected directly from experimental participants. A validation plan shall be developed to demonstrate the utility of the developed tool, with alternatives to be implemented with both DOD and non-DOD personnel. The validation plan shall be executed utilizing DOD personnel if circumstances allow, or with non-DOD personnel if circumstances do not permit access to DOD personnel. All data to be used for validation shall be collected from experimental participants or sources other than DOD personnel systems. Although integration of the prototype tool with DOD personnel systems is not required, respondents should be mindful of the nature and types of data on military personnel normally available to commanders in personnel jackets.

PHASE III DUAL USE APPLICATIONS: The prototype tool developed here will hold substantive military and commercial potential for application. In military settings commanders and leaders at all levels may benefit, whether tasked with assembling a team for operational assignments or a task force for resolving organizational problems. As noted earlier, joint, multinational operational headquarters are particularly susceptible to personnel underutilization as the differential deployment periods create a relatively high level of staff turnover. If successful, the prototype tool could be the basis for the development of a specific application to minimize the impact of staff turnover on organizational performance and maximize staff utilization. Private sector organizations, which are increasingly relying on teams, may similarly benefit from the developed technology to assess and influence the extent to which personnel utilization for team assignments is optimized to accomplish organizational goals.

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KEYWORDS: Personnel assignment, team staffing, team composition, team performance modeling

A06-061 TITLE: Flexible Electronics for Rugged, Low Power Army Systems

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop thin film transistor drivers on flexible plastic substrates with novel materials, low temperature processes, scalable vertical or self-aligned transistor structures, and n- and p-type (CMOS) technology. The transistor designs must be compatible with large area processing for flexible display applications.

DESCRIPTION: The performance of current amorphous and polycrystalline silicon thin-film transistors with a low temperature process (<200C) for flexible substrates cannot meet flexible reflective and emissive display applications. For traditional glass substrates, amorphous and polycrystalline silicon thin film transistors are processed above 300C with acceptable performance and yield, which is too high for traditional plastic substrates. This technological shortcoming suggests the need to develop novel materials and low-temperature processing for the active layer, gate dielectrics, electrodes, and device structures with improved yield. The technology is sought to improve the threshold voltage shift as a function of stressing. Improve the charge mobility for increased current density as a function of drain voltage. Develop materials that lead to lower process temperatures with lower internal stresses. The lower stress will improve the mask alignment run-outs on plastic substrates. The materials and transistor designs are also sought that lead to reduced number of masks steps for higher yield. The material improvements are sought for gate dielectrics, electrode metals and active layers. The proposed program should compliment the Army's Flexible Display Center to develop flexible displays for soldier and vehicle applications. These new designs and the associated devices should be capable of higher performance, improved stability, higher yield, lower cost and improved scalability over the current state of the art technology.

PHASE I: Proposals are sought for thin film transistor (TFT) development in any one of the following areas: novel materials to achieve low temperature processes; novel device structures for vertical transistors; and CMOS driver designs. Phase I must demonstrate the performance of a single thin film transistor. Initial devices may be fabricated on glass substrates to demonstrate technology advances, but the processing must be compatible with plastic substrates such as polyethylene naphthalate (PEN), polyethylene terephthalate (PET), or equivalent. The process temperature limit must be less than 200C. Further, the designs must fit within known design rules for flexible substrates. The Phase I deliverable will be a report on the performance and processes.

PHASE II: The technology and transistor structure designs enabled in Phase I will be scaled up to designs with at least 1,000 thin film transistors (TFTs). The technology must be demonstrated on plastic substrates with process temperatures less than 200C. The program requests delivery of functional TFT array(s) consisting of at least 1,000 TFTs on flexible substrates. The active area will be at least a 4 inch diagonal. The TFT test array may be display driver arrays for current driven pixels or voltage switches. Similarly, the functional TFT arrays may be applicable to sensors, RFID tag technology or similar electronics applications. The final devices will be delivered to the Army Research Laboratory for further evaluation. In addition, quarterly reports documenting progress will be delivered to the Army Research Laboratory. Full TFT arrays on plastic substrates may require additional handling efforts such as lamination and delamination that are beyond the scope of Phase II.

PHASE III: Thin film transistors on flexible substrates and the associated applications offer significant possible commercialization for novel display applications and other electronic devices. The military has a strong interest in incorporating flexible substrate based displays and electronics into advanced military systems.

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KEYWORDS: Thin film transistors, flexible substrates, displays, materials, device structures, processes, process tools

A06-062 TITLE: Compact, Lightweight Ultrafast Laser Source for Field Sensors

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: To develop a new ultrafast (femtosecond) laser source suitable for field use in a variety of spectroscopy field sensors, but especially for those based on microplasma emission spectroscopy. Techniques such as Laser Induced Breakdown Spectroscopy (LIBS) have recently demonstrated the ability to detect and discriminate chem, bio, and explosives hazards both in close-contact and standoff modes. Currently the LIBS devices that have been and are being developed for field use are based on nanosecond lasers and have certain limitations that can be overcome through the use of femtosecond lasers. However, to date, femtosecond lasers have been too large, bulky, delicate, and expensive to be considered as viable candidates for field use. This SBIR is aimed to develop a new and innovative femtosecond laser source to bring femto-LIBS into field use.

DESCRIPTION: The Laser Induced Breakdown Spectroscopy (LIBS) technology has recently started to make a significant impact on military and civilian sensor needs, especially in the areas of force protection and homeland security. For example, the MP-LIBS (man-portable/backpack) version in presently being transitioned to the nation’s civilian and military First Responders. The MP-LIBS sensor utilizes the traditional nanosecond-range Nd:YAG laser since this type of laser is rugged, mature, and very suited for field use. The current MP-LIBS system uses a very small laser package to produce around 35 mJoule per pulse energy that is needed to produce the microplasma. Unfortunately, the nanosecond laser source has certain less than desirable features such as: (1) it is always accompanied by broadband background emission, (2) the LIBS spectra usually exhibit matrix effects which lead to undue pulse to pulse variation, and (3) the approximately 10 microsecond microplasma lifetime ensures that there is mixing of ambient air with the sample leading to compromised H, O, and N atom emissions. This latter limitation can be addressed through the use of the dual-pulse approach, but at a cost of system complexity and some increase in size and weight. The hydrogen, nitrogen, and oxygen emission signals are important for many measurements such as for detecting trace explosives where the nitrogen to oxygen ratios are key indicators of highly oxidized/explosives compounds. Matrix effects are a major contributor to excessive pulse-to-pulse variability. In recent years researchers have demonstrated that femtosecond LIBS improves the matrix effect problem by yielding more reproducible ablation and the microplasma phenomenon is too short to allow for mixing with ambient air. Laboratory femtosecond lasers tend to be large, complicated, and expensive. New and innovative technology developments are required to develop femtosecond laser sources suitable for field femto-LIBS applications. Ideally, a new femtosecond laser for LIBS use would be of approximately the same size, weight, and cost as the current nanosecond Nd:YAG lasers of the type that are used in the MP-LIBS system. In general, the preferred femtosecond laser specifications would be >0.1 mJoule per pulse energy, pulse duration lower than 100 femtoseconds, and low beam divergence. In particular, femtosecond fiber lasers appear to show considerable potential to meet the size, weight, performance, and cost targets for fieldable LIBS systems.

PHASE I: Develop and demonstrate key optical performance features of a femtosecond laser that will clearly support the construction of a small, fieldable laser suitable for LIBS in Phase II. Generate a detailed optical design for the femtosecond laser system.

PHASE II: Construct the rugged fieldable femtosecond laser prototype, demonstrate its applicability for LIBS analyses, and deliver complete working femtosecond laser LIBS system to ARL for testing. System must be sufficiently rugged so as to be capable of being demonstrated in a field environment.

PHASE III: A femtosecond LIBS field sensor will allow for a significant increase in the number of applications that LIBS can be used for, especially for the detection of trace explosives and chem.-bio agents due to the ability to accurately track the O, N, and H atoms in the target material. Beyond military applications, such a femtosecond laser system could be used widely in the medical and biomedical fields, as well as for geological, geochemical and environmental applications.

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KEYWORDS: Femto-LIBS, field sensors, chem-bio sensors

A06-063 TITLE: Fluctuation-Enhanced Chemical & Biological Sensor Systems

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: The design and development of a portable chemical-based sensing system that will possess a significantly enhanced ability to detect and selectively analyze chemical (and potentially biological) agents, at ppm concentrations and below, through the utilization of a recently discovered stochastic fingerprinting methodology.

DESCRIPTION: The envisioned technological demonstration should be built upon recent scientific breakthroughs in the understanding of stochastic processes present in the detection signals of traditional chemical sensors. Here, the fluctuation activity has been shown [1] to contain valuable sensor information that can be obtained not only by spectral analysis but also by methods of higher-order statistics. Indeed, the interaction between a chemical sensor and the molecules it detects is always a dynamic stochastic process. Fluctuations that result from these processes carry a “stochastic fingerprint” of the chemicals (and potentially also from interacting biological molecules) that arise from the time-dependent interactions with the sensor. Microscopic fluctuations around the mean value of the sensor signal contain significantly more information than the mean value alone, yet the vast majority of existing chemical sensors measure averages and ignore the stochastic nature of the sensing process and therefore show low performance. This conventional approach is limited because it intrinsically masks the micro-fluctuations present in the sensor, effectively treating the tremendous amount of potential chemical information as noise and disregarding it. Specifically, a single quantitative value is used as a sensor output instead of a whole pattern which can be derived from the stochastic signal components. Conventional sensor systems must also be tuned to detect specific agents in order to optimize performance against those agents. This tuning, on the other hand, radically reduces the effectiveness of the sensor system against other potentially threatening agents. Also, to achieve a measurable signal over the error limit, a huge number of molecules have to be absorbed by the sensor, thus the sensitivity is often inadequate in low-concentration detection cases.

Therefore, a new program is proposed to investigate the potential of a new technological approach based upon Fluctuation-Enhanced Sensing (FES) that utilizes the micro-fluctuations already present in the sensor and that are influenced by very low concentrations of chemical (and also potentially by biological) agents. This approach has analogies elements to that used by animal noses which are believed to produce stochastic-fluctuation-type signals that are analyzed by the animal's brain. A significant body of theoretical and experimental research has emerged in recent years that suggest commercial-off-the-shelf (COTS) chemical sensors can be significantly enhanced using the FES technique [2-17]. For example, research has shown that the sensitivity of COTS chemical sensors operated in fluctuation-enhanced modes is increased by 1000 times and that the selectivity is increased even more significantly [4-6]. These improvements are due to the fact that stochastic information (derived from individual sensors) were utilized to estimate concentrations and to achieve identification of chemical species, and it is expected that small arrays of sensors have the potential to further improve performance and reliability. Very recent research has also demonstrated that two-dimensional stochastic patterns, generated by methods of higher-order statistics (HOS), offer even more elaborate and useful information for chemical sensing [1, 10-13]. In this work, the nonlinear stochastic properties of commercial Taguchi-type (i.e., surface-active gas-sensing films) sensors were studied and HOS tools were used to analyze the resistance fluctuations that resulted from exposure to various gas mixtures. Here, an analysis of the Gaussian and non-Gaussian components of the induced noise led to bispectrum images that possessed "chemical fingerprint" features that were unique to each gas type. Since it was also possible to produce bispectrum images of high accuracy and reproducibility at low sampling frequencies, these new results suggest profoundly important opportunities for FES-based chemical (and possibly biological) detection. Therefore, a research and development program is proposed to investigate the potential advantages of fluctuation-enhanced sensor platforms and to demonstrate their utility towards the detection and the selective analysis of chemical (and potentially biological) agents.

PHASE I: The first phase of the program should focus on feasibility studies of utilizing Fluctuation-Enhanced Sensing (FES) techniques for the detection and analysis of chemical agents at very low concentrations, and scenarios for potential extensions of the technique for biological agent sensing. This effort should also establish quantitative predictions and initial experiments studies to determine the advantages of this technique for the characterization and discrimination of chemical and biological agents. This work should be performed in the context of enhancements to COTS sensors and should include efforts to establish a preliminary bispectrum-image database and software for assessing overall signature interpretation capability.

PHASE II: The second phase of the program should be used to design and demonstrate an FES-based platform that is constructed using COTS sensor technology. This sensor prototype should be compact and should exhibit enhanced performance in the terms of chemical (and possibly biological) agent detection and selective analysis capability. It is expected that the new sensing paradigm will consist of a small array of COTS sensors, utilize bispectrum imagery and incorporate imaging processing software to optimize signature interpretation capability. The prototype should also be developed so that it is amenable to battlefield deployment and such that operation is as autonomous as possible – i.e., with minimal operator calibration and tuning. The operation capability of the sensor system should be tested against a set of chemical (and possibly biological) agents that have relevance to military defense applications.

PHASE III: The fluctuation-enhanced sensing technology developed under this topic has important relevance to reducing the threat of chemical and biological warfare agents. Therefore, the primary commercialization opportunity is for detection/identification sensor systems which have important relevance to both the military and private sector to reduce the threat of adversaries and terrorist groups. However, this technology will also target capabilities for selective analysis of agents and therefore has duel use potential in areas related to biological, chemical and environmental science and to food-safety and medical applications.

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KEYWORDS: stochastic fingerprinting, fluctuation sensing, chemical and biological detection

A06-064 TITLE: Dynamic Ad-Hoc Network Communications Visualization and Control

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop an intuitive visualization of the state, information flow, and needed modifications of a wireless dynamic ad-hoc network supporting dismounted infantry (platoon size) in urban environments. The visualization would include identification of choke points and potential relay drop off positions. The network will be composed of individual war fighters, robots, and relay drop-offs. Critical communication paths will be determined and coverage will be augmented by actively repositioning autonomous robotic relay points to ensure and extend coverageto the desired end points.

DESCRIPTION: The United States Army is most vulnerable in urban terrain. This highly constrained, complex environment presents a significant challenge to US forces, particularly dismounted infantry. In order to enhance situational awareness in the urban terrain, future dismounted squads will be augmented by networked mobile and static sensing assets; unattended ground sensors, small unmanned ground and air vehicles.

Each will also act as a mobile sensor and communications node since they will be equipped with sensors such as GPS, imagers, laser , and will be networked locally. This organic sensor and communications augmentation of dismounted squads is consistent with the Future Combat System (FCS) and Future Force Warrior (FFW) concepts. The foundation of this enhanced situational awareness (blue and red) as well as team collaboration is the ability to communicate these streams of information in real time to the platoon members.

Wireless, secure, ad hoc networks are envisioned to be a critical part of the solution in this complex, highly dynamic environment. Because of this criticality, understanding the state and potential of the network becomes important to the platoon and needs to be an inherent part of their situational awareness. Providing an intuitive visualization to the platoon of their network in context for both planning and operations will significantly enhance their mission effectiveness and survivability. Providing the ability to direct semi-autonomous assets to critical areas of coverage that can ensure network connectivity, will allow critical information to reach its destination. This ability will provide a higher probability of mission success.

Key areas of research for this topic include coping with urban terrain and simple communications models, minimizing cognitive load on the soldier, and application to mixed teams of humans and robots. Though many models exist for RF propagation in complex terrain, along with mobility algorithms and models for small robotic vehicles, this RFP proposes exploring the combination of RF propagation to predict areas of weak connectivity, and then direct semi-autonmous small robotic vehicles to verify prediction model and provide RF coverage for that area.

PHASE I: Utilizing an approved wireless ad hoc network model and a standard mapping system, design an innovative communications visualization system, and deliver a well documented report on the design and implementation approach. Implementation approach must demostrate that the end product can be achieved through application or extension of existing technologies, and that the proposed effort is within the scope of this SBIR.

PHASE II: Implement and demonstrate an integrated wireless ad hoc network communications visualization system for the dismounted soldier, utilizing existing small robotic vehicles.

The end product must be capable of visualizing communication paths for the selected network model over a given terrain data base (DTED) utilizing a standard mapping system. Given a desired tactical objective on the displayed terrain, the developed system should indicate areas of emplacement for most effective communication coverage. The system must also be able to provide way points to semi-autonomous small robotic vehicles, equiped with ad hoc network nodes. The developed system must be able to direct vehicles to desired locations. The designed system must be able to account for robot mobility and must also be able to verify predicted communications preformance and area coverage, once vehicles are in place.

Selection of visualization/mapping system, adhoc nodes and robotic platforms are at the contractor's discretion. These can be provided by the government (GFE). If GFE, technical specifications for these items will be provided.

PHASE III: Technology developed on this program will have commercial applications for police and firefighters, search and rescue, and homeland defense.

Military applications would include: extending communication/networking capability into urban terrain, buildings, caves, other high risk areas for humans that would not otherwise have direct line of sight communications. Civilian applications would include: providing communications in areas that have lost existing infrastructure due to natural disasters or terrorist activity; communication in high risk areas such as collapsed buildings, areas under sniper fire, bomb threat etc.

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2. C. Santivanez, R. Ramanathon, and I. Stavrakis, “Making Link-State Routing Scale for Ad Hoc Networks”, Proc. ACM Mobihoc 2001, Long Beach, CA.

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KEYWORDS: visualization, situational awareness, ad hoc networks

A06-065 TITLE: High Sensitivity Rugged Array Detectors for Field Deployed Instruments

TECHNOLOGY AREAS: Chemical/Bio Defense, Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: To develop new very high sensitivity array detectors operating in the ultraviolet-visible range (200-1000nm) that compare favorably with current laboratory detector performance and can readily be used as detectors for field deployable instruments. In the laboratory, Intensified Charge Coupled Devices (ICCDs) are commonly used as detectors in Laser Induced Breakdown Spectroscopy (LIBS) experiments to observe emission from laser induced microplasmas. ICCDs, however, are expensive, somewhat bulky devices that are not generally suitable for rugged field use. Current generation CCDs are smaller, less costly, and more rugged, but suffer from low sensitivity. [1] Thus, a new array detector technology is sought that provides the performance of present laboratory ICCD-based LIBS detector systems, but is more rugged, smaller, and much less expensive than ICCDs. The SBIR addresses the need for more efficient, more rugged, cheaper, and lightweight detectors for optical spectroscopy techniques that are being deployed for field use.

DESCRIPTION: Currently Laser Induced Breakdown Spectroscopy (LIBS) technology is being transitioned to both military and civilian field use in a number of specific configurations, including MP-LIBS (man-portable/backpack), ST-LIBS (standoff), and FO-LIBS (fiber-optic). In the last few years LIBS has demonstrated exceptional ability to detect various types of hazards including trace explosives, chem/bio, and toxic industrial chemicals (TICs). A major challenge in LIBS technology is the detection of weak ultraviolet-visible radiation emanating from the microplasma with high sensitivity and good signal-to-noise performance. The CCD arrays that are currently being fielded do not have the sensitivity of the laboratory ICCD systems, leading to a compromise in spectral detection performance with regards to signal-to-noise ratios and spectral resolution. [1-3] New innovative array detectors are sought that will provide: (i) sensitivities of an intensified sensor device, (ii) full operation from the ultraviolet to the near infrared region (200-1000nm), (iii) gating capability down to the microsecond time resolution for optimal LIBS performance, and (iv) cost that is comparable to the CCD arrays currently being used in very compact spectrometers. Target improvements in array detector sensitivity are a factor of 100, with a factor of 10 being the minimum that would be acceptable. The cost target is for these arrays, when packaged into spectrometers, to cost no more than a factor of 2 over current spectrometer systems. This would mean that the cost is no more than 1/4 of current ICCD spectrometer systems.

One example of current LIBS technology thrusts is the detection of explosive residues for counter- Improvised Explosive Devices (C-IED) applications. A major challenge for standoff IED detection is the weaker LIBS microplasma emission as the standoff distance is increased. An array detector that can provide performance of an ICCD system but which is smaller, more rugged, and much less costly, will greatly expand the utility of LIBS in field applications as a manned or unmanned surveillance tool.

PHASE I: Develop and demonstrate a novel single detector element (point detector) that is capable of being developed into an array in Phase II and that compares favorably in sensitivity and time response to current ICCD detectors in capturing the transient spectral light emission from a LIBS microplasma event. Describe a detailed engineering approach to produce an array detector early in Phase II.

PHASE II: Construct the detector array based on the novel detector material and integrate into a spectrometer for close-contact and standoff LIBS studies at ARL. The overall size and weight of the detector/spectrometer shall not be greater than current non-intensified compact spectrometers used in field LIBS systems, yet the sensitivity (signal output) should be at least a factor of 10 greater than the current non-intensified units. This novel detector array must maintain the low noise levels of current non-intensified systems. The cost of the new detector array must be within a factor of 2 in quantity to the cost of current non-intensified detector arrays.

PHASE III: A next generation array detector will have a major impact on a variety of LIBS configurations where the greatly improved sensitivity and ruggedness will allow for smaller and less expensive sensor devices for both civilian and military applications. A robust, cost effective detector could be utilized for other types of optical spectroscopies as well, such as Raman and Laser Induced Fluorescence.

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3) Wainner R T, Harmon R S, Miziolek A W, McNesby K L, French P D, Analysis of environmental lead contamination: comparison of LIBS field and laboratory instruments. SPECTROCHIMICA ACTA PART B-ATOMIC SPECTROSCOPY 56 (6): 777-793, JUN 2001.

KEYWORDS: CCD, field sensors, chem-bio sensors

A06-066 TITLE: Compact Direct Methanol Fuel Cell Power System Using Pulsed Electrical Control

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a compact direct methanol fuel cell power system that utilizes pulsed electrical control of the cell stack as a means to maintain high electrocatalytic activity. The hybrid power system should deliver a constant 20 W for 72 h with a minimum system energy density of 1 kWh/kg.

DESCRIPTION: The Army has need for high-energy, lightweight, and compact power sources for the soldier; for example, one potential scenario requires 20 W (electric) for a three-day mission (1.5 kWh) with a system energy density of 1 kWh/kg or greater. In principle, a direct methanol fuel cell (DMFC) using a polymer electrolyte membrane (PEM) would fulfill this need, but a number of factors prevent reaching this target. For example: areal power density of a DMFC is low (in comparison to a hydrogen/air fuel cell), which necessitates a greater number of cells with commensurate increase in stack weight and volume; low areal current density (relative to hydrogen/air fuel cell) limits the methanol concentration due to an otherwise unacceptable parasitic methanol crossover through the PEM to the cathode (air side), thereby lowering system efficiency; water vapor in the exiting cathode gas must be condensed and reused, requiring added complexity and weight/volume in a condenser and air mover; etc … Operation of the DMFC at greater current densities, while still maintaining a high cell voltage relative to the equilibrium potential, would alleviate these problems and provide an improved DMFC power system.

The state-of-art electrocatalyst in a DMFC is Pt/Ru as the anode and Pt as the cathode. It is generally accepted that a CO or CO-like surface adsorbate forms on the anode as a reaction intermediate during methanol electrooxidation and poisons otherwise high-catalytic activity Pt electrodes (e.g., 1 and references therein). The Ru in the Pt/Ru electrocatalyst mix provides adsorbed oxygen for the oxidative removal of the poison to maintain reasonable catalytic rates of methanol electrooxidation. Clean polycrystalline Pt has intrinsically high-catalytic activity for methanol electrooxidation but the reaction rate quickly drops to unacceptably low values at potentials relevant to power systems as the poisonous adsorbate accumulates on the surface. It was apparently first recognized by Bockris (2) that poisonous adsorbates can be electrochemically removed in situ by short duration, high-current pulses in which the electrode potential is brought sufficiently anodic during the pulse to oxidize surface species. It has been demonstrated in half-cell studies that Pt can be electrochemically cleaned of surface adsorbates formed from methanol electrooxidation in acid aqueous environment (3).

The application of short duration, high-current pulses to a PEM DMFC should, in principle, provide an anode surface of high-catalytic activity on average over the periodic-pulse cycle. Advantages may also accrue on the cathode side if oxy-adsorbates (known inhibitors to dioxygen electroreduction at the cathode) are reduced in the pulse sequence. Pulsed-potential control of a single-cell has been recently reported to effect enhanced performance of a PEM DMFC (4). Periodic electrical control has also been recently reported to effect increased performance of a reformate/air PEM fuel cell in which adsorbed catalyst poison CO is electrochemically removed during the pulse from the anode (5). Challenges remain to be addressed, however, before the potential of this control strategy to improve performance of a compact DMFC power system can be assessed. Questions to be examined include: Can a cell stack be operated in a pulsed-control mode without detrimental effect to individual cells in the series? A possible and unacceptable outcome, for example, is potential reversal in one or more cells in the series. Are there detrimental long-term effects on the distribution or chemical stability of the electrocatalysts subjected to periodic potential perturbations? The integrity of the electrocatalysts and carbon support materials must not be detrimentally affected by the time-varying control mode. What is the best pulse-control mode? Because, either the current or stack potential can be readily manipulated, it is imperative to determine if one is more advantageous than the other. What is the optimal control waveform? Rectangular-shaped waveforms (pulse) have been used in laboratory studies although it is not clear that these are the best control to implement in a practical manifestation of the strategy. What electronic and energy-storage devices are required to implement the control? The weight, volume, complexity, and cost of the control circuitry must be considered as well as the means to store energy in the pulsed mode and deliver a steady power supply to the user. What is the effect of the pulsed-control strategy on balance-of-plant components? It remains to be determined if the complexity of the control mode is counterbalanced not only by increase in performance of the cell stack but also a decrease in weight and volume of other system components. These and other issues will be examined under this topic, which focuses on this novel control strategy and its effect on system performance. Compelling arguments or experimental results will need to be supplied by respondents to justify use of other than state-of-art DMFC components in the cell stack.

PHASE I: At breadboard level, identify and evaluate a pulsed-control strategy applied to a PEM DMFC stack as a means to enhance performance. Quantify the performance increase and compare with state-of-art PEM DMFC under steady control. The DMFC stack must contain a minimum of five cells that deliver 3 W. Pulsed-control strategy must be applied and evaluated in a continuous 100-h run. Identify, implement, and evaluate the circuitry and energy-storage hardware to affect the pulsed control and deliver a constant (time-invariant) power output. Based upon these results, provide a conceptual design and project the performance characteristics of a complete and self-contained 20-W compact power system.

PHASE II: Design, construct, and evaluate a compact soldier portable DMFC PEM fuel cell power system with a minimum system energy density of 1 kWh/kg for 72-h operation at a steady 20 W delivered power production. Evaluate performance of the power system for a minimum of 500 h continuous operation. One complete 20-W power system is to be delivered to the Army.

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

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4) W. A. Adams and C.L. Gardner, Paper 1513, Proceedings 207th Meeting of the Electrochemical Society, 2005.
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KEYWORDS: direct methanol fuel cell, compact power system, pulsed electrical control

A06-067 TITLE: Stereoscopic 3D Viewing of Single-sensor Video from Moving Surveillance Platforms

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To design and develop a system for providing time-sequential video-delay in a binocular display for videos taken from a single sensor on a moving platform that can be viewed in true stereoscopic 3D. This capability would incorporate a viewer-adjustable "time-slip" video delay for one eye relative to the other eye and also the capability for the video to be paused, reversed or fast forwarded, during which the degree of perceived binocular depth in the scene could be adjusted by the viewer. Key objectives include the ability to create stereoscopic video from live or stored video and the creation of a user interface for pausing, playing, rewinding and fast-forwarding the video and for setting the magnitude of the time-slip inter-ocular delay.

DESCRIPTION: The Army Research Laboratory Human Research and Engineering Directorate has been involved in assessing the utility of stereoscopic 3D displays for the performance of Soldier tasks requiring extraction of spatial information from a scene. Such stereoscopic displays have been shown to provide significant performance improvements over 2D (monocular or bi-ocular) displays of the same scene (CuQlock-Knopp et al., 1995; Merritt et al., 2005). The stereoscopic percepts produced in these studies were obtained by displaying separate, simultaneously recorded and time-synchronized Left and Right video streams to observers' left and right eyes. This technique is well suited for military situations in which the Soldier is viewing a stationary scene or is moving in a largely forward direction through a scene, such as when traversing off-road terrain or driving a vehicle at night using image intensifiers or thermal imagers. However, video supporting this technique needs to be captured by pairs of precisely aligned sensors and the storage of the video requires either a time-synchronized pair of video recording/playback devices or some means of multiplexing or compressing the video streams into a single stream -- a process that typically results in some degree of image degradation.

A time-sequential stereo technique has two distinct advantages over traditional simultaneous stereo pairs and would be well suited for a large subset of Army reconnaissance and surveillance tasks. First, stereoscopic video or still frames can be generated from any video taken at a side-looking angle from a moving platform without any additional image processing. Secondly, the described technique allows for the effective distance between the virtual sensors to be quite large, thereby allowing for the percept of depth and object-to-background contours (i.e., binocular disparity due to occlusion) at great distances. The Army's Future Combat System (FCS) calls for the proliferation of unmanned assets on the battlefield, from micro-UAVs to large, armed ground vehicles. In addition, ongoing military action in Iraq and Afghanistan have called into service a number of unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) to support our troops in the asymmetric battlefield of today. Many of these systems, particularly UAVs, have as part of their mission the ability to perform reconnaissance and surveillance. The proposed capability would provide human analysts an enhanced ability to interpret surveillance footage of terrain and enemy forces deployed with little or no modification of the UAV or UGV platform or sensors.

PHASE I: The goal of Phase I is to demonstrate the feasibility of observer-adjustable time-sequential stereoscopic video. Specifically, the Phase I system should demonstrate how video taken from a sideways-pointing sensor mounted on a moving ground or aerial platform can be used to generate useful 3D visual percepts of a scene. The system will use as input a single video stream from the sensor and will provide as output two video streams, to be displayed to the left and right eye of an observer. One of the streams will be delayed some time delta-t relative to the other stream to create an effective inter-ocular distance (IOD) by which two sensors viewing the scene would be separated. The magnitude of the delay will be adjustable in real time by the user. The system will be able to process digital images to ensure that time-delayed image pairs are vertically aligned against roll and pitch of the platform and that the delayed video stream is sent to the appropriate eye of the viewer. The playback of the video to the observer will have two sets of controls: one similar to those on a digital video recorder (e.g., pause, play, fast forward, reverse) and one that controls the time delay between frames. The time-delay control will operate at all playback speeds, including pause, so that different effective IODs can be examined. The Phase-I system will also include as a deliverable some commercial off-the-shelf means for displaying the two video streams to the observer's left and right eyes for stereoscopic 3D viewing.

PHASE II: During Phase II the capabilities of Phase I should be augmented to produce a small-profile, fully-featured, ruggedized prototype with an easy-to-use user interface. The Phase-II system will support advanced video image processing, allowing the system to remain useful in a variety of situations and for a variety of tasks not well supported by Phase I. Situations would include when sensors are mounted obliquely on the platform and when the platform moves non-linearly. (Both situations will lead to mis-alignment and size disparities between scene elements in the two output streams and must be compensated for digitally or limited in severity.) . Form-from-motion techniques will be employed such that exact scene geometry can be calculated based on the horizontal and temporal disparity of subsequent frames of video. This geometric information will include the distance from objects, the heading of the platform with respect to the scene, the effective camera spacing in units of distance or units of convergence angle. This information will allow the viewer to set constraints to be met by the system automatically changing delta-t: maintain a constant convergence angle while viewing the scene, or maintain a constant time-delay while viewing the scene. The system will provide this information to the user in the form of overlays inserted binocularly into the output video streams. Two complete systems with supporting documentation will be delivered in Phase II.

PHASE III: The time-sequential stereoscopic video device will have widespread applications in situations wherein human observers must view and inspect objects or terrain moving with respect to a sensor. Examples include the inspection of products moving down an assembly line, wherein video from a stationary camera will allow inspectors to perceive the three-dimensional shape and surface characteristics of the product, and analysis of aerial video taken by police or Drug Enforcement Agency surveillance and inspection assets.

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KEYWORDS: time-sequential stereo, stereoscopic 3D video, surveillance

A06-068 TITLE: Effects of Damage to Composite Materials

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: To develop a method/tool to characterize the effects of damage to a composite material on its overall structural performance and modal properties. Given that damage has occurred (hole(s), delamination, cracking, etc.) to the composite material, the developed tool shall determine what effects this damage has on the structural performance (e.g., strength) and behavior (modal responses) of the material or overall structure.

DESCRIPTION: Composite materials are being used more frequently, particularly for armor and structural applications, in current combat vehicles and will continue to be used as the requirements for light-weight strength extends into the future. The characteristic properties of composite materials are more complex and thus it is more difficult to accurately understand and predict their behavior. Of particular concern for the Army is the effect that damage to the composite has on its vulnerability within a combat environment.

The Army currently utilizes a shock model with the capability of predicting damage to critical components mounted internally within combat vehicles. The current shock methodology assumes undamaged materials when performing

calculations. However, holes and other damage can not only cause a decrease in structural performance but can also alter the modal properties of the structure thus causing changes in the structural response calculations. The capability to determine the vulnerability of degraded structures, specifically how the damage effects structural response and integrity, would greatly enhance vulnerability modeling.
The reduced performance of a composite structure when damage has occurred is of interest. The damage may range from actual holes in the material to simple ply delamination. But in either case, it is desired that the degraded performance of the structure be quantified is some manner. Current vulnerability codes are unable to incorporate complex structural codes, like finite element analysis. Thus, engineering level models need to be developed that can characterize trends and damage mechanisms to quantify structural performance degradation.

PHASE I: 1. The contractor shall design and develop the methodology/tool to determine effects of composite material damage on structural performance and modal responses of vehicle panels and structures. The input to such a tool could be hole size and location, delamination, and/or maximum deflections.

2. The contractor shall show the feasibility of this new method through the use of test cases and show the feasibility of it being implemented in a practical engineering manner.

PHASE II: The contractor shall extend the Phase I methodology to the full capability of a productive tool. The new tool shall be capable of determining the reduced performance of a composite structure when various degrees of damage occur in the composite material. The new tool shall be a complete software package that meets the requirements set forth in Phase I, and have basic verification and validation efforts conducted to show it effectiveness.

PHASE III: The creation of this tool will have a broad range of commercial applications. Not only will it directly impact structural modeling capabilities, it will also be applicable to civilian defense issues. Commercial applications can range form the aircraft industry to the auto and shipping industry.

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KEYWORDS: Blast, composite materials, structural response, ballistic vulnerability

A06-069 TITLE: <u>Structural Damage Effects to Army Vehicles</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To develop a new method/tool to characterize vehicle failure and/or residual vehicle capability as it relates to structural damage that is caused by a ballistic environment. Where residual vehicle capability is defined as the capabilities (like mobility, fire power, etc) that remain based on the level of damaged imparted to the vehicle. Conceptually the new tool can be thought of as an advanced fault tree concept that is based on structural damage of the vehicle. This new tool shall be capable of analyzing both existing and future vehicle technologies to the effects of the ballistic environment that includes fragments and a blast effect.

DESCRIPTION: Future Army systems are becoming more lightweight and thus are becoming more susceptible to conventional weapons. The thinner walled vehicles of advanced materials allow a greater transmission of energy to the internal components and are also more vulnerable to rupture due to the blast environment. The Army has been utilizing computer aided design (CAD) modeling tools with complex survivability analysis tools, like MUVES S-2

(Modular Unixed-Based Vulnerability Estimation Suite) to determine the survivability of ground vehicles to conventional weapons effects for many years. The blast effects from these weapons have largely been ignored because the ground targets have been so robust. The Future Combat Systems (FCS) will be a lighter weight system of systems and blast effects will have a greater impact then ever before. A new stand alone module that can determine the residual vehicle capabilities (like fire power, mobility, etc) due to damage effects of the fragments and a blast induced environment is needed to complete the overall MUVES-S2 modeling suite. Given the structural damage in terms of a maximum deflection, perforation, material failure, or composite cracking and/or delamination the tool must be able to correlate these structural damage mechanisms to reduced capabilities of the overall system/vehicle.

PHASE I: 1. The contractor shall design and develop the methodology/tool to determine the vehicle residual capabilities as it relates to structural damage induced by a conventional ballistic environment. The structural damage will be given (known) from a separate analysis conducted by ARL. Thus input to the new tool could be a maximum deflection, a perforation, a material failure, or a composite cracking and/or delamination. This type of damage information along with the known location of the damage would be the starting point of the new model. This damage information will be generated from experimental data as well as from analytical modeling techniques. The proposed methodology shall consider advanced lightweight materials as well as basic materials such as aluminum and steel. The reduced capability can be quantified in various ways. It can be given as a limiting speed to travel, a distance to travel, an amount of times the system can fire its weapon, etc.

2. The contractor shall show the feasibility of this new method through the use of test cases and show how it could be linked to higher level vulnerability computer codes including the MUVES S-2 computer code.

PHASE II: 1. The contractor shall extend the Phase I methodology to the full capability of a productive tool for ballistic analysis. The tool shall be capable of relating structural damage (like panel failure) to the residual vehicle capabilities. The new tool shall be a complete software package that meets the requirements set fourth in Phase I, and shall interface with the MUVES S2 Computer code.

2. The new tool shall also be validated through a series of experiments and analytical studies.

PHASE III: The creation of this tool could have a broad range of commercial applications. Not only will it directly impact ballistic modeling capabilities, it will also be applicable to civilian defense issues, and the commercial airline industry.

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3) Title: Techniques for Predicting the Structural Vulnerability of Combat Aircraft to Ballistic Impact, Corporate Author: (Not Available). Personal Author: MEISELMAN, J. J.; BURCH, G. T.; AVERY, J. G. Report Date: July 01, 1971.

KEYWORDS: blast, shock, survivability analysis, MUVES S2, residual capabilities

A06-070 TITLE: LIBS-Based Deminer’s Probe for Buried Landmine Detection

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Battlespace

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To develop an innovative soil-insertable LIBS sensor for the detection and discrimination of landmines from other buried object such as rocks, roots, and anthropogenic clutter) in the subsurface.

DESCRIPTION: Not only are landmines a threat on the battlefield, but they remain a significant problem for civilians around the world in areas of current and former conflict. Some 15,000 - 20,000 people in more than 90 countries fall victims each year to the more than 80 million land mines present in more than 80 countries world-wide [1,2]. These cannot be efficiently removed using current humanitarian demining approaches [3]. At present, landmine detection is generally conducted in a manner not that dissimilar to that employed half a century ago. A hand-held metal detector is used to identify a subsurface anomaly that may be a buried landmine. In humanitarian demining, meter wide lanes are searched for anomalies while swinging a metal detector back and forth just above the ground surface. After receiving a signal from the metal detector, the suspected area is probed to determine whether or not it contains a buried landmine. This is also the general procedure used for military post-operational landmine clearance, although a prototype handheld system that combines a metal detector with a ground-penetrating radar was deployed for the first time in 2003 on a limited basis by US forces in Afghanistan. To investigate the detected anomaly, a human deminer then uses a thin, tapered prodding device for decision making about the nature of the detected anomaly to determine if it is a solid object and, if so, whether or not it is a landmine. This is a very tedious and sometimes uncertain approach. Thus, there is a particular need for a deminer's soil prodder that will differentiate between buried anti-personnel mines and other subsurface objects [4].

Broadband Laser Induced Breakdown Spectroscopy (LIBS) has been shown to be a sensor technology capable of discriminating among different types of plastic landmine casings through a statistical approach that compares the full 200-980 nm LIBS spectrum acquired for an unknown sample against a spectral library [5,7]. The discrimination of different explosive and energetic materials using LIBS has also been demonstrated [6, 7]. Thus, LIBS has the attractive possibility of being a single-sensor technology with the potential to detect and discriminate both the casing of a landmine and its explosive contents. The recent development of the man-portable/backpack LIBS sensor system (MP-LIBS) [7], which utilizes the traditional nanosecond-range Nd:YAG laser that is mature, small, rugged and very suited for field use, has opened up the possibility for the development of LIBS as a confirmatory sensor technology for landmine detection.

The concept for a complete man-portable LIBS system for landmine detection and discrimination is a backpack-size system in which a mini-laser is contained in the prodder handle and laser light is delivered to the tip of the probe and plasma light collected by optics in the body of the probe. In such a configuration, analyses could be made readily and reliably by touching the buried object that one is interested in identifying. A spark would be created and a plasma generated on the surface of a buried object when encountered by the probe, after one or two preliminary 'cleaning' shots to remove surface soil particles and expose a fresh material surface. The resultant light would be captured by the optics in the probe tip and transmitted through the prodder and handle to the broadband spectrometer. The spectrum obtained would be background corrected by software in the on-board computer and then compared with a spectral library of landmine casings, explosives, and a variety of common environmental clutter objects to determine if there was a positive correlation. A spectral match with a reference spectrum in either the landmine casings or explosives library would be declared a positive response that required marking and excavation in a 'heads-up' display. The objective of this SBIR topic concerns the construction of an innovative prodder/probe that maintains the functionality of current de-miner's probes but allows for the capability of the LIBS technique at the tip of the probe which will be underground surrounded by soil.

PHASE I: The design of LIBS-based deminer's prodder and development of a 'breadboard' prototype. The probe would be similar in form and material composition to the current generation of prodders currently in use within the humanitarian demining community, i.e., having a thin, ~30-40cm long, end-tapered probe of non-metallic composition (e.g., grade 3CR12 stainless steel) that joins a barrel-style handle. The handle will contain a pulsed Nd-YAG laser capable of delivering at least ~30mJ pulse energy per shot. The laser radiation will be directed via a set of internal optics that will both transmit the laser signal and returned plasma light to a man-portable LIBS-spectrometer system contained in a backpack worn by the user. The probe will also allow for the passage of an inert gas (e.g., Ar) to the tip of the probe, and the tapered tip of the probe will be designed to protect the optics from both damage and soil obstruction during insertion. The Ar gas flow serves to increase the LIBS spectral signal as well as allows for improved detection of the actual explosives that may have migrated from the landmine and are located in close proximity of the mine. The capability of the Phase I breadboard system to propagate and focus pulsed nanosecond laser light to a buried target flushed by Ar in a sandbox, as well as to capture the resultant microplasma emission, will be demonstrated under laboratory conditions. This can be done in coordination with the ARL LIBS research group located in Aberdeen Proving Ground, MD.

PHASE II: Development of a full prototype LIBS-based deminer's prodder suitable for field use and delivered to ARL for testing.

PHASE III: The development of a handheld probe for man-portable LIBS analysis will have the potential to be used as a confirmatory sensor for both humanitarian and military demining, but would also find wide use in a wide variety of applications where real-time, chemical analysis under field conditions is needed (e.g., homeland security, forensic, environmental cleanup, geoscience, and bioscience applications) where it is necessary to determine the chemical character of a substance in real-time, undisturbed in the field.

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KEYWORDS: deminer's prodder, LIBS, man-portable LIBS, in-situ chemical analysis, landmine detection & disrimination

A06-071 TITLE: Awareness and Recognition of Behavioral Threat within Complex Environments: Detection of Intent from Biomotion Signatures

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The goal of this SBIR initiative is to develop a biomotion signature generation and recognition technology that will facilitate the identification of hostile, friendly and neutral players within a common operational environment, with special concern for backdrops characterized by complexity (e.g., high density military operations in urban terrain, i.e., MOUT). Given that the protection of the individual warfighter, the safety of the deployed force, and the timeliness of information processing to ensure such security are assigned highest priority during mission planning and execution (TRADOC PAM 525-66) for both the current and future force, such a technology would significantly impact the safety and effectiveness of tactical operations. Questions that should be addressed and resolved during development include the following:

• What are the regions of interest when scanning populated, dynamically changing environments?
• How do overt biomotion threat signatures parametrically differ from more subtle, covert biomotion threat signatures?
• How do the perception and neural instantiation of biomotion-derived threats differ from neutral/friendly biomotion signatures?
• How will a technological application achieve anticipatory biomotion threat signature detection for monitoring and/or direct action?
• How do eye-movement cluster patterns, electrophysiological signatures, and behavioral performance characteristics change with increased exposure (e.g., from naïve observers to street-savvy individuals, from infantry scouts to covert operatives)?
• Is there degradation in detection efficacy with increased distance? What technological solutions might remedy such losses, should they become apparent?
• How does perspective (i.e., viewing plane) impact detection of intent signatures from biomotion (e.g., aerial intelligence stream vs. localized, ground-based intelligence)?

Gains from this effort will inform the following programmatic Army initiatives:

• Manpower and Personnel Integration domain of soldier survivability
• Army Cognitive Readiness Initiative
• ARL Strategic Neuroscience Thrust
• Development of biometric-based surveillance systems
• Technology for Human-Robotic Interaction Army Technology
Automated sensor technologies to assess biomotion signatures
• Enhanced Learning Environments with Creative Technologies Army Technology Objective: improved immersion and realism for simulations fed by biomotion threat signatures

DESCRIPTION: The human ability to detect implicit intent based on non-verbal signals is executed by most individuals in an effortless, instinctive manner. However, the breadth and depth of personal experience with specific behaviors characterized by physical threat or otherwise overt hostility allows certain individuals to recognize and react to such activity, preemptively, relative to individuals whose awareness of such actions may be dangerously delayed due to a naiveté in these domains. The ramifications of this faculty for commanders and tactical operators, who must immediately recognize, distribute and act upon real-time operational intelligence is readily apparent. Patrols within urban landscapes continue to provide challenges to the individual warfighter, whose survival and effectiveness is dependent upon reliable, immediate analysis of the dynamics of crowds, the behavior of marketplace patrons, or individuals in transit through the immediate area of operations. Though the deployed current force faces these challenges daily, planning for future force operational doctrine has acknowledged this issue as a targeted specification, such that the future Brigade Combat Team (BCT) "…is designed and equipped to develop a situation before contact (TRADOC PAM 525-3-90)". One way to achieve such preemptive awareness is through detection and identification based on biomotion signatures, which may provide anticipatory intelligence well in advance of overt operational threats.

PHASE I: 1. A comprehensive literature review that examines the bases of non-verbal transfer of communicative information. The review should include, but not be limited to the topics of sensory vs. perceptual roots of detecting and recognizing intent, the inability to determine implicit communicative detail among autistic or brain-damaged patients (right-hemisphere localized), the ecological vs. information processing roots of deciphering implicit intent, the predictability of the sequencing and temporal dynamics of bodily motion, and bases for the subjective attribution of intent.

2. A feasibility analysis for a technology that dynamically isolates joint locations, categorizes movements, assigns biomotion signatures, classifies threats, and is functional in a dynamic and hostile setting.

PHASE II: A field practical pilot study to validate the technology (proof of principle). Upon validation, biomotion signature detection technologies may be employed within both military and civilian frameworks where security concerns are a priority.

PHASE III: Commercialization potential for the current proposal will include industrial fields spanning the military, law enforcement, and private security services. The operational dynamics of public transportation systems, urban centers, and large meeting venues (e.g., shopping centers, stadiums, arenas) could derive particular security benefits from the development of the proposed technologies.

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KEYWORDS: biomotion; biomechanics; social cognition; amygdala; automaticity; intentionality; superior temporal sulcus

A06-072 TITLE: <u>Mobile Toxic Hazard Transport and Diffusion Analysis and Prediction Tool</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Starting with a database of Hazardous and/or Toxic materials, input of weather information and a Geographic Information System (GIS) capability; design and code a portable tool based on a Personal Data Assistant (PDA) that provides a map of the location of a hazardous release and the expected path and concentration of the material.

DESCRIPTION: With the advances in the capabilities of PDA's, it is possible to store more information on flash disks, communicate data quickly in several communication methods, display higher resolution maps on PDA screens, and perform small amounts of computations in relatively short time. A toxicology database has already been migrated to PDA's as well as weather tactical decision aids. What is missing is the addition of forecast weather fields for predicting the transport and diffusion of the material from a hazardous/toxic spill and the ability to ingest real weather from surface observations or remote sensors (to keep the weather field up-to-date). Being able to visualize toxic plumes in relation to the locations of the first responders and in relation to significant sites while enroute to a hazardous material spill, would greatly protect first responders, local command posts and the most susceptible citizens.

PHASE I: Develop an overall design for equipping an existing PDA to access weather data, have a hazardous / toxic chemical database resident on it or its flash memory, and be able to display a map of the local area with responder and plume locations on it. Carefully consider and document the mode of communications to be used under different operational conditions and the breakdown of which items would be most effectively computed on the PDA, which best would reside on flash memory, and which would be most effectively transmitted to the PDA on one of the communication modes (and how often this would be necessary). Conduct a feasibility study to determine effectiveness in a hazardous release emergency. Consider the following weather related information:
a. Weather Prediction Models. The most effective of these are generally considered too compute-intensive to run on a PDA. Typically runs of 5 to 15km grid spacing are available in the field near the command center from the Integrated Meteorological System (IMETS) and soon from the Distributed Common Ground System - Army (DCGS-A) at Future Combat System (FCS) vehicles in the field, but these would not be useful by themselves in this task. Show how much data would have to be downloaded and provide a means to download this information.
b. High-resolution Diagnostic Models. These more quickly calculate the higher-resolution weather fields based on the output of the above weather prediction models updated with up-to-the-minute observations and using higher-resolution terrain and land characterization. These range from 2D (Cionco, 1985) to 3D with several vertical levels

(Scire, et.al, 2000). One of the models of this category should be used, but it must be a model for public release. For this topic, low resolution with such models would be 1km grid spacing. High resolution would be 50m or less. A domain using 200x200x10 grid points is a goal but 50x50x10 would be acceptable.
c. Transport and Diffusion Models. These range from models using just one surface wind observation and a fixed angle of diffusion (considered inappropriate to the task) to full LaGrangian Particle models using 4D model output (which may be too compute intensive for the PDA). The recommended model would be a Gaussian puff model using the full 4D model output field such as (but not limited to) CALPUFF (Scire, et al., 2000). Whichever model is selected, it must respond correctly to the time and space varying winds and the terrain.
d. Local Surface Observations. It is envisioned that surface weather information will be available on the battlefield, from either automated sensors placed in the field or from the Soldiers themselves (Every Soldier is a Sensor). Provision for acquiring this information, merging it with raw observations from IMETS or DCGS-A, and using it to update the forecast from IMETS or DCGS-A is required.

Although there is much documented work on GIS systems, weather modeling, transport and diffusion modeling and toxic chemical hazards on larger computers (Olvera, 2004), and even Tactical Decision Aids (TDAs) (Sauter & Torres, 2004), navigation, GIS and a toxic chemical library on PDAs (Next Century Corp, 2005), the innovation required here is to determine a way to quickly and effectively get the information to the dismounted user in the field by efficient communication of a smaller set of data from a larger computer (IMETS or DCGS-A), without transmitting extremely large sets of data, or spending large amounts of time on PDA computation.

PHASE II: After decisions to choose the "best" methods of meeting the objectives, then:
a. Develop and demonstrate a prototype PDA-based hazards monitor based on an existing PDA. It would be necessary to see all the parts required on the PDA for this project in place using simulated data, and simulated communication of those data that would reside off the PDA.
b. Develop methods to update the weather, toxic chemical release information, and hazard source location while away from the required database sources to simulate update enroute to the emergency.
c. Show how the capability to be resident on the PDA can be included in the DCGS-A environment.

PHASE III: Participate in a test emergency response to hazardous spills using the PDA to site the command post and first responders before arriving on the scene, showing that the system can give response enroute to an emergency by uploading the location of release and the latest weather on the fly. This system could be used in a broad-range of military and civilian applications where release of hazardous materials and the efforts to provide environmental cleanup could affect soldiers, general populace, or first responders. This could occur on military bases, in industrial areas, along interstate highways or near railroad tracks. Knowing where the material will be transported in the air will greatly help to protect lives.

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KEYWORDS: PDA, GIS, Hazard, Prediction, Weather, Transport, Diffusion, Communication

A06-073 TITLE: Lightweight Structural Energetic Composites for FCS Munitions

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: To perform enabling research and development that will lead to the creation of a radically new generation of multifunctional materials (lightweight structural energetic composites (SEC) for Future Combat Systems (FCS) munitions that are composed of organic energetic polymer composites). The term “Composite” is a well-accepted and generally refers to structural components with enhanced mechanical performance. The creation of SECs that contain energetic materials, such as energetic polymer materials or fills, will enhance not only the strength, stiffness, and fracture resistance of munitions components, but provide energy to the overall system. A key objective is to replace inert munitions structural components with energetic structural materials that: contain no metals; can be used in propulsion systems and leave no solid combustion products; provide energy and gaseous combustion products.

DESCRIPTION: There are a wide variety of programs in reactive materials that utilize metal/metal, metal/metal oxides, and polymer/metal materials to provide enhancements to warheads. There is now significant interest, with potential broad applicability in munitions, to exploit the energy of a new generation of materials (unlike reactive materials) that can provide high-energy output per gram while concurrently providing a high-degree of structural integrity for advanced gun propulsion applications. The proposed work seeks the creation of SECs that contain energetic materials, such as energetic polymer materials or fills, that will enhance not only the strength, stiffness, and fracture resistance of gun-launched munitions components and propulsion systems, but provide energy to the overall propulsion system. A key objective is to replace inert munitions structural components with energetic structural materials that: contain no metals; can be used in propulsion systems and leave no solid combustion products; provide energy and gaseous combustion products. Key applications of SECs will be as replacements for combustible cases (tank ammunition cases, modular artillery charge cases, and mortar propellant cases); energetic laminates for sabots and projectile bases; consumable igniter tubes, and components for gun-launched munitions. SECs will be an enabler for more effective, efficient, lethal, and survivable munitions designs. Key technical challenges to be addressed are (1) developing SECs and understanding and evaluating the energy release characteristics, (2) developing modeling capabilities that could be used to assess their performance and lethality under a variety of conditions, and (3) developing and understanding the processing and manufacturing characteristics. A multidisciplinary research and development approach for SECs will be focusing on mechanics, materials science, physics, chemistry, modeling, and numerical simulations to identify and characterize these processes, as well as development of capabilities to predict the response of macroscopic events based upon these microscopic processes.

PHASE I: Define and provide supporting analysis on all promising NEW SEC materials for applications as outlined in the description.

PHASE II: Design, fabricate and test prototype SEC materials to validate 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 is inserted/transitioned into several Army programs for weapon development efforts (120 mm Tank Ammunition (LOS); 155 mm Modular Artillery Charge System (MACS) [NLO]; 120 mm Mid Range Munition (MRM)).

Excellent dual use applications for combustible cartridge cases for commerical small caliber ammunition (billions produced on a yearly basis) - eliminate brass cartridges, eliminate lead containing igniter materials.

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KEYWORDS: Energetic composites, cartridge case, laminates, structural energetic materials

A06-074 TITLE: Design and Development of a Micro Solid State Cooling Device for Harsh Battlefield Environments

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To develop the materials testing, integration, and process science required to prototype a micro solid state cooling device for harsh battlefield environments. The technology developed must be light weight, small size and low cost and capable of integration with individual soldiers clothing.

DESCRIPTION: In battle field environments reliable compact refrigeration systems are critical to maintain vital life support temperatures for soldiers, as well as for high power electronic systems, and temperature critical sensors (i.e., infra-red, night vision etc.). Traditional heat pumps for cooling and heating are based on vapor compression cycles. These cycles require compressors and pumps that limit the level of miniaturization that can be achieved. Additionally the many moving parts make conventional systems prone to mechanical failure. Alternative solid state thermoelectric cooling devices are more robust, but are prone to low efficiencies, and require a large power source to operate. Development of thermoelectric cooling is fairly extensive and will not be consider under this SBIR.

Novel thermal cooling technologies and concepts are being considered using active or “smart” material concepts. These include but are not limited to magnetocaloric materials that can absorb and release heat through a phase transformation process. Possible materials with an electrical or photo induced phase change could be used to shuttle thermal heat for a heat pump as well. Devices employing these concepts can provide true thermodynamic refrigeration cycles with large thermal cooling capacities and large temperature ranges. The device would be solid state and scaleable from the miniature level to the micro scale, environmentally friendly, and extremely robust and reliable. The solid state heat pump has the promise to revolutionize the current market for refrigeration systems and create new ones from their extended capabilities. Some envisioned commercial applications would include portable refrigeration units for food, and biological specimens, more reliable cooling systems for aerospace and the automotive industry.

PHASE I: Phase I of this program will develop a cooling concept utilizing a novel phase changing material. A through processing methodology will be developed and subsequent testing and characterization of the material will be performed. Integration of the material into a possible heat pump device should be investigated and analysed. A final constitutive model to estimate the cooling performance with baseline figure of merit comparison to alternative technologies is required.

PHASE II: At the conclusion of Phase I, a prototype design and numerical simulation that will demonstrate the viability of the concept will be completed. A specific application for the micro cooling will be selected and the prototyped designed. The prototype must exhibit the capability to pump a minimal 20° C difference, have a footprint less than 16 squared inches. Testing and characterization of the prototype will be conducted to fully evaluate its performance. Cooling capacity, efficiency, range, and cooling rate will be evaluated. An analysis of scaling effects will be conducted to provide performance effects at smaller scales.

PHASE III: A manufacturing and large production scale up strategy will be developed. Foundry friendly process protocols, as well as other standard manufacturing technology will be utilized to the utmost to ensure a feasible transition to commercialization. Phase III will determine the manufacturability of this system for cost effectiveness in the context that it could be used in a broad range of military and civilian applications. Thus, subsequent to prototype demonstration, a manufacturing process will be developed and demonstrated. The feasibility of alternative products will be investigated.

This solid state heat pump could be used in a broad range of military and commercial applications such as cooling for the soldier in the battlefield, light-weight cooling systems for the aerospace industry, and components cooling in power electronics.

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KEYWORDS: Active materials, cooling, heat pump, refrigeration, phase change, latent heat, micro scale, electronics

A06-075 TITLE: Simulation Tools for Strain Engineering, Manufacturing and Design of Novel Optical and Electronic Superlattice Materials and Surfaces

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: To develop simulation capability for engineering, manufacturing and design of novel materials and surfaces with nanoscale features arranged into superlattices. The key outcome will offer trade-off principles for manufacturing parameters of new types of devices.

DESCRIPTION: Superlattices consist of alternating layers of two different semiconductors. The lattice misfit-induced strain causes interesting new behavior by deformation-potential effects: It changes the band gaps of the constituent materials and splits the degeneracy of the zone-center heavy- and light-hole bands [1]. The flexibility of tuning the electronic band structure of the semiconductor superlattices has applications in novel design of semiconductor diode lasers, electro-optical modulators, nonlinear optical devices, infrared imaging systems, etc. Recent nanoscale science and engineering has opened various new frontiers, with perhaps one of the most dynamically growing areas still being in electronic devices and semiconductor physics. Fabrication and growth of quantum wells (QWs), quantum wires (QWRs), and quantum dots (QDs) structures based on different semiconductors and compounds are reported weekly with various novel features being observed for potential applications in optoelectronic and sensor devices. Current trends in the commercial sector have already identified the benefits and weaknesses of strained-silicon-based semiconductor design [2].

To tailor and modulate the optoelectronic and other properties in QD structures, the size, shape, and distribution of the QD superlattice need to be precisely controlled. Therefore, from the device application point of view, QD superlattices should have high density, narrow size distributions, and good spatial ordering, with known material properties. Experimentally, however, accurate control of these parameters are extremely difficult due to the fact that they depend on various factors, including temperature, flux rate, spacer thickness, diffusion character, system energy, among others. The material properties, on the other hand, are directly related to the underlying atomistic physics. Thus, a reliable modeling and simulation tool is in urgent need which could help to understand the effect of various factors and provide vital information for designers and experimentalists in controlling and accelerating fabrication of QD architectures. Furthermore, the lattice-misfit induced elastic/electric fields in QD superlattices need to be accurately predicted with full reconstruction capability so that reliability studies on the mechanics of the structure can be carried out. The elastic/electric fields are also important inputs for the control and modulation of the energy bandgap which is the key to strain energy band engineering.

Recently, a variety of numerical simulation models have been proposed for epitaxial growth study of QD superlattices, spanning from atomistic to continuum with multiscale methods linking them [3-7]. Among these models, those centering on event-based kinetic Monte Carlo (KMC) technique to simulate the heteroepitaxial growth of QD superlattices have shown promise [8]. The marginal use of elastic strain generated by the monolayer islands has been shown to be instrumental in inducing narrow size distributions and good spatial ordering [8]. Moreover, the direct and simplified continuum mechanics (CM) model [9,10] has further shown that the long-range elastic interaction with different growth orientations is the key factor to the observed correlation and anti-correlation features.

Current KMC-based modeling methods still have some limitations when applied to self-organized QD superlattice growth. First and foremost is the lack of specificity and experimental validation. Theoretical materials, while informative, lack sufficient material details that would lend relevance to real laboratory materials and conditions. Secondly, long-range elastic strain effects are based on overly simplistic models that are hard to justify for real materials. We seek methods that realistically handle cubic and non-cubic lattices for materials such as wide band-gap group III-nitrides with full atomistic features, where appropriate, and accurate long-range effects,.

Besides the precise growth of QD superlattices, and perhaps even more importantly, there is a pressing need for the corresponding mechanical study of the structure, and subsequently, the profound effect of the induced and fully coupled strain/electric fields on the energy bandgap. These are extremely important and urgent issues for the next-generation fabrication and mechanical/electronic modeling of QD superlattices. Particular emphasis is on reliability and multifunctional/conformable materials and sensors.

PHASE I: Develop methods to apply modern computational, numerical techniques and sophisticated computer modeling methods to the conceptual design and manufacture of sensors based on superlattice material structures. Particular emphasis shall be placed on the potential of applying the models to Army-centric sensor designs. Methods that exploit the parallel nature of the numerical methods for easy and direct application to high performance computing are especially welcomed. Identify engineering studies on design trade-offs of manufacturing processes and operational capabilities of fabricated devices that can be further explored in Phase II. Successful completion of Phase I will also identify benefits and limitations of the methods through feature-comparison with other competing methods for their ability to accurately model design trade-off scenarios of the manufacturing processes and projected operational capabilities of devices.

PHASE II: With the background established in Phase I, this part of the effort will be to implement and develop a robust software tool. Both theory/method and software development are warranted. The outcome will be a turn-key solution for engineering simulations and design of optoelectronic manufacturing processes of QD superlattices. Realistic processing scenarios modeled through kinetic Monte Carlo algorithms coupled to molecular dynamics and continuum mechanics on high performance computers are favored.

PHASE III: Phase III of the project will focus on development for dual use applications. Significant dual use will be made of the outcome primarily in semiconductor design and quantum dot devices. The effort will draw attention to improving materials modeling for alternate chemical species that are more readily found outside of the defense sector. These developments will be based on the same computational engine as the Phase II effort and center more on modules development for other types of materials (atoms). Main thrust will be for testing and validation of software. Collaboration with commercial entities will be encouraged.

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KEYWORDS: quantum dots, sensors, optoelectronics, kinetic monte carlo, software developement, modeling, simulation, multiscale, design

A06-076 TITLE: Novel, Low Cost Superhydrophilic Anti-Fog Coatings to Maintain Transparency

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: Design and develop a robust processing and fabrication technique to exploit nanotechnology for deposition of superhydrophilic coatings to provide anti-fog capability to glass as well as to transparent polymeric-based substrates.

DESCRIPTION: The Army has identified an urgent need for transparent armor systems that are lightweight and capable to provide a greater extent of protection to the individual soldier as well as to the armored vehicles against emerging threats. One of the major drawbacks of the currently fielded transparent armor platforms is their vulnerability to fogging. Emerging high performance materials are also likely to fog. When fogging occurs, tiny water droplets condense on the surface which cause light-scattering and often render the surface to become translucent. This is common particularly when a cold surface suddenly comes in contact with warm, moist air such as a soldier’s breath. Fogging severity can ultimately compromise the transparent platform capabilities, and often jeopardize the soldier’s survivability simply because they need to remove their protective eyewear or face shields to be able to see. Current commodity anti-fog coatings often diminish after repeated cleanings over time and require constant reapplication to ensure their effectiveness. Recent advances in nanotechnology have the potential to enable superhydrophilic surface coatings with anti-fog characteristics that prevents the formation of water droplets. Superhydrophilic coating technology will provide the Army with significantly enhanced soldier and vehicle survivability by preventing battlefield’s fogging hazards. Additional benefits of anti-fog coatings include improved light transmittance, service performance durability and a significant reduction in logistic costs.

PHASE I: Demonstrate feasibility of synthesis and processing of superhydrophilic anti-fog coating for deposition onto glass as well as polycarbonate substrates. Determine the anti-fog efficiency and environmental durability including the adhesion onto coated glass and polycarbonate plates. Demonstrate that the coating does not diminish visibility. It is desirable that the coatings can be applied to both individual protective systems and vision blocks for ground vehicles. Identify the potential material candidates for use to produce prototypes in Phase II.

PHASE II: Refine and optimize the materials synthesis and application process. Develop a low-cost fabrication process with scale-up capabilities to produce prototype coated vehicle window systems that meet the performance specifications of both glass and polycarbonate. One of the following top candidate prototypes shall be subjected to durability evaluation including resistance to scratch and abrasion as well as to field testing for validation of anti-fog efficiency: coated Sun-Wind-Dust (SWD) goggles, riot face shields, and chemical/biological protective lenses for face masks. Ballistic testing of coated polycarbonate plates and selected prototypes including SWD goggles and Riot Face Shields shall be conducted to ensure the performance requirements for protection against a 0.22 caliber fragment simulating projectile.

PHASE III: Potential military dual use applications include Sun-Wind-Dust goggles, laser safety eye protective spectacles, chemical/ biological protective face masks, ballistic shields for explosive ordnance disposal personnel, and vision blocks for light tactical vehicles. There is a very high probability for commercialization for applications such as sport goggles, auto windshields, windows in public transit vehicles, armored cars for law enforcement and VIP protection, and solar panels and green-house enclosures.

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KEYWORDS: Anti-fog Coatings; Superhydrophilicity; Transparent Lightweight Armor; Nanotechnology.

A06-077 TITLE: High Power Density Gears Using a Systems Engineering Approach for Selection, Test, and Evaluations of Emerging Materials, Surface Engineering, and Tribology Solutions

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Demonstrate capability to develop high power density gearing by a systems engineering approach including development and application of economically viable test and evaluation methods. The concept is to develop methodologies to evaluate and apply combinations of emerging technologies for materials, heat treatments, surface engineering on a continuous basis.

DESCRIPTION: Gear systems for next generation air and ground vehicles for military and commercial applications will require high power density gears to meet demands for improved durability, reduced operating costs, improved fuel economy. Efforts to improve power density for gears have typically sought to advance one particular aspect of the gear system (for example, a new alloy, a new coating [Ref. 1], a new surface modification [Ref. 2], etc.). Such an approach has met with only limited success, perhaps since increasing power density relative to current state-of-art requires improving the power capacity relative to multiple potential failure modes (bending fatigue, spalling, pitting, micropitting, scuffing and scoring, impact fracture) while meeting other operational requirements (such as operating temperature requirements, corrosion resistance, compatibility with lubricants, and military helicopter drive system requirements for oil-off capability). The cost of gear component testing inhibits the rapid assessments of emerging technologies in the areas of materials, processing, and lubricant improvements.

This effort should define a methodology to select and then evaluate combinations of emerging technologies that could be applied to increase gear power density. This may involve the development analytical software and/or one or more test machines using cost-effective test samples. The test specimens and test machines must produce performance data representative of gears. The analysis methods and test data should enable engineers to optimize gear performance for a particular application by an economical process to incorporate emerging technologies in a synergistic fashion. The offeror should consider methods to evaluate any or possibly all of wear, surface durability, scoring (scuffing), friction and efficiency, fracture toughness, bending durability, and compatibility with lubricants by appropriate combinations of analyses and test. After completion of an effort the offeror should be in position to: (1) use a standardized, documented procedure to select potential combinations of promising technologies, (2) evaluate the selected technologies by analysis and specimen testing, (3) be able to define specifications for procurement of gear test specimens for proof- of-performance gear testing, and (4) be in position to again apply the methodology on a continuous basis as new technologies emerge in the areas of materials, processing, surface engineering, lubrication, and tribology.

The focus of this topic is gear component technology (materials, processing, and surface engineering) and influence of lubricants. Novel gear systems technologies (such as new gear tooth geometries, novel arrangements of gears, hybrid electro-mechanical drive systems, etc.) will not be considered for award. Only proposals that show realistic potential for assessment of emerging technologies on a continuous basis will be considered for award.

PHASE I: Define requirements for evaluation of emerging technologies for gear applications giving consideration to all possible modes of gear failure. Define analysis and test requirements to optimize combinations of treatments leading to downselect for proof-of-concept gear testing. Develop specifications for economical test specimens and test machine(s). Identify needs for accompanying analysis tools. Select emerging technologies for evaluation during Phase II.

PHASE II: Complete test machine fabrication and test methodology. Develop any identified analysis tools required to make use of the empirical data from the test machines. Procure test specimens and complete testing to assess performance, testing multiple combinations as budget allows. Analyze the test data and define performance limits of the selected technologies. Downselect to a single concept, specify and procure gears for evaluation on gear test rigs to enable final proof-of-concept and benchmarking of the newly developed methodology and test machine(s).

PHASE III: Military markets include developers of aircraft gear systems and ground-based systems and research organizations. Commercial markets include developers of ground vehicles, aircraft systems and industrial gear systems.

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KEYWORDS: gears, materials, tribology, test and evaluation, lubrication, surface engineering

A06-078 TITLE: <u>New and Improved Nonaqueous Electrolyte Components - Salts and Solvents</u>

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: The Army has multiple requirements for higher performance longer life power sources with a wider operating temperature range. Develop new and improved electrolytes enabling the development of Li-ion batteries capable of operating in a temperature range from -40 to 70 degrees Centigrade with improved storage/cycle life, power performance, and safety in a large format.

DESCRIPTION: The electrolyte is one of the key components in broadening the operation temperature ranges without sacrificing the storage/cycle life at temperatures above 55 degrees Centigrade and the power performance at temperatures below -20 degrees Centigrade. The electrolyte also impacts the safety of the Li-ion batteries. Safety becomes a critical issue when the battery size gets larger. Therefore, the research of chemically, electrochemically, and thermally stable and conductive electrolyte is critical for achieving high power density and high energy density energy storage devices for future Army applications in soldier power, hybrid electric vehicles, and pulse power sources.

PHASE I: Identify and demonstrate new and improved electrolytes containing new and improved salts, solvents, or a combination of salts and solvents in a laboratory cells over the state-of-the-art electrolytes. Basic chemical, electrochemical, and thermal properties are characterized preferably relevant to Li-ion cell environment.

PHASE II: Fabricate sufficient quantities of new and improved electrolytes based on the formulations developed in Phase I research. Evaluate and demonstrate the new and improved electrolytes in industrial prototype cells such as

18650 or larger sizes. Evaluation should include storage/cycle life test at temperatures above 60 degrees Centigrade, power performance at temperatures below -30 degrees Centigrade, and overcharge safety test. Mechanism for improvement should also be investigated.

PHASE III: Optimize new and improved electrolyte formulation for selected Li-ion anode and cathode material system. Fabricate industrial prototype cells of sizes larger than 18650 for long term performance and safety evaluations. Participation of an established Li-ion battery manufacturer is encouraged in this Phase of development.

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KEYWORDS: lithium salt, ester solvents, addives, nonaqueous, lithiumion cells

A06-079 TITLE: <u>Identification of Cultural Demographics to Predict Community Responses to Military Operations</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The objective of this SBIR is to test a proof of concept that interactions among demographic variables can be extracted from a population data set (either electronic or text or both), that these interactions can be extracted at the national, regional, and local levels, and that these can be visually displayed on a command interface in such a way to reduce uncertainty in decision making during urban operations. The effort here is not to determine which demographic variables may be of interest at the strategic to tactical levels, but rather to identify interactions between variables and to develop display technologies that can help a command staff rapidly develop a holistic understanding of a region. For example, religious affiliation is an important variable. At one level of abstraction, it may appear true that followers of one religion would not support a new democratic leader in Iraq, and would support an insurgent effort. However, if this variable interacts with other variables such as income and age, for example, the original assumption may be incomplete. We might expect that followers of this particular religious party, when of an upper income group and older age cohort, would be more likely to support the democratic party and be unsupportive of insurgent rhetoric. This information would be important for a command staff to have because it would give them a finer grasp on the likelihood of population groups to be influenced by information operations or other military activities.

DESCRIPTION: Displays that translate text data to visual interfaces must be pursued and included on battle command systems. One promising technology capable of this translation is computer data mining. Socio-economic data can often be viewed as revealing multiple attributes of very many entities. For example, for many wards or precincts, data about ethnicity, housing, voting history, average income, etc. may be known. Computer data mining techniques and associated software programs allow the user to interactively explore data sets graphically and to use the data collected about the many entities to learn about the relationships between their different attributes. Visual displays in the data mining process are used to understand the relationships between variables. These displays may include: two-dimensional plots of continuous or discrete attributes against one another, histograms of frequency of occurrence of attribute values, lists and tables, and stacked one-dimensional plots to see the distribution of attribute values on each criterion of interest. Sensitivity analysis is also a recommended data mining activity, discovering to what degree various attributes appear to be affected by fluctuations in others.

In the Phase I SBIR process, the data mining process would be undertaken for either the Afghanistan or Iraq regions, based on the availability of adequate population based data and socio-economic text data. A report on the interactions between the socio-economic variables would be prepared, identifying the interaction patterns at the strategic, operational, and tactical levels. For each of these levels, information would become more refined and specific. Additionally, the region of interest would be scaled, moving from the nation (strategic) to province (operational) to the town (tactical). Data treatment technologies and display techniques should be considered and recommendations made. However, the emphasis should not be on creating a data mining engine, as this technology already exists. Rather, the emphasis would be on the interactions between variables, the interpretation of how these interactions would impact a command staff's understanding of the area in a holistic sense, and suggestions on how this information could be visually displayed on a battle command interface.

PHASE I: Conduct a literature search to gather more data on how socio-economic data has been collected and used in recent military operations. A primary source of information would be 'lessons learned' documents. The review should discuss how the data should be structured to accommodate the three levels of command (strategic, operational, and tactical). This addresses the issue of the scalability of data. Consider relevant data treatment technologies, such as statistical routines and group display techniques that would be appropriate for the development of a graphical user interface of this type. Explore the data display techniques that would be most appropriate for this type of information. Consideration should be given to visualization techniques and various types of displays that allow the rapid integration of information. The conclusion of Phase 1 would be a report that includes these topics above. The focus of this effort is not to reinvent the importance that demographic information plays in understanding the sensitivities of a region of interest, but to document the differences in scale that exist between the national, regional, and local levels. Also, the problem of how to represent this information in a visual display is a part of this Phase 1 effort. Normally, demographic data is presented primarily in text format and is lengthy due to the need to describe the interactions between variables. A command staff won't have the time to wade through a large text document but instead, would benefit from an interactive display that presents information through pictures, graphs, or other methods and that permits scaling down to get more details in certain fields.

PHASE II: The second phase of the SBIR would explore the data display techniques that would be most appropriate for this type of information. Consideration should be given to visualization techniques and various types of displays that allow the rapid integration of information. In this phase a prototype interface would be formulated that would be tested in a pilot study. The focus of phase II would be to validate the contributions that a display of this nature makes to decision making in an urban environment. A major challenge in Phase II would be to scale the information to strategic, operational, and tactical users. Included in that challenge is the problem of how to tailor the information in an interface. Should one interface be developed? Three? How does population data change with different units of analysis? How can we scale military effects so that they correspond to the national, regional, and local areas of concern?

PHASE III: This technology has potential application for military staffs operating in peace keeping operations. In these situations, the focus is on returning a nation to its pre-war state of stability and rule of law. However, the internal groups that disagreed on National policies must be supported in their efforts to achieve a new state of equilibrium. As our experiences in Bosnia and Kosovo have shown, the military presence is essential in the fragile years of rebuilding and peacekeepers must have an excellent knowledge of the host nation's history and current needs. To use the Bosnia example, this tool would use text and data base material for a data mining effort that would allow the command staff to remain current on socio-economic trends and sensitivities. As these variables are not static, the ability to use data mining of current documents such as newspapers and census files is critical for updated statistics. In Bosnia, as internally displaced persons returned to their homes, the demographic structure of regions changed in a significant way.

A commercial application of this technology would be useful for businesses seeking to better understand their customer base. One might imagine a tool such as this would be particularly useful for colleges who seek to understand in more detail the demographic needs of their student population.

A spin-on capability could be to use a tool such as this with societal level models that seek to predict unintended consequences from military actions taken in a combat or peacekeeping mission. Or, this kind of technology could potentially help community planners and military reserve and guard units who struggled in the wake of Hurricane Katrina.

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KEYWORDS: data mining, culture, demographics, predictive analysis, community response

A06-080 TITLE: Coatings for Field Repair of Transparent Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this research is to develop a nanoparticle filled coating that will repair scratches and other damage to goggles and other transparent materials caused by sand abrasion. After application, optical transparency will return to a functional level with little to no degradation in performance.

DESCRIPTION: Transparent armor (e.g., goggles, windscreens, blast shields) provides a critical capability for soldiers by protecting their eyes with little or no visual obstruction. Recently, in environments such as Iraq and Afghanistan, sand induced damage has become a serious issue. Soldiers have found that abraded and scratched surfaces significantly degrade optical clarity and the usefulness of goggles.

Recent basic research results in the ARO Polymer Science Program show promise for a simple, effective solution to this problem. Research results have predicted (1, 2, 3) and experimentally confirmed (results are pending publication) that nanoparticles can be functionalized such that when incorporated into a compatible polymeric coating, they will selectively migrate into cracks and abrasions at the air-surface interface. The goal of this Topic is to build on these results to design an easy to apply coating that contains particles that will selectively migrate to cracks, adhere to the surface, and restore optical transparency without distortion. Research will focus on tailoring particle size, composition, aspect ratio, surface functionalization, and coating formulation. The resultant technology should be designed such that a company supply sergeant can easily use it to repair damaged goggles and other transparent materials.

PHASE I: Initial research will focus on identifying promising particles and base coating formulations. Issues that may need to be addressed include nanoparticle composition, size, shape, functionality, coating solubility, UV/Visible adsorption, refractive index, glass transition temperature, optical clarity, and photo and temperature stability. Processing studies will be carried out to characterize and address nanoparticle dispersion within the base coating formulation. An understanding of interface adhesion between nanoparticle, base polymer, and transparent material will be developed. Reliable metrology (i.e., ASTM International Standards, using for example, ASTM F548-1, -03, -081) will be identified and used in proof of concept experiments to evaluate success and failure criteria (i.e., optical clarity, distortion, adhesion, durability) for suitable coatings applied to scratched and abraded transparent materials. Repair coatings will be demonstrated on a statistically significant number of specimens of a minimal sample size (5 x 5 cm), as determined in the metrology.

PHASE II: Experiments will be performed to demonstrate that nanoparticles migrate to defects and that optical clarity and transmittance are maintained. An understanding of nanoparticle segregation into surface defects of predefined type and size will be developed so that the limits of the technology are understood. Optical clarity, optical transparency limits, reflectance, and distortion will be defined using reliable metrology and reported for uncoated, coated, and recoated systems. Interface adhesion between nanoparticle, base polymer, and transparent armor surface will be characterized and optimized for typical environmental conditions involving blowing sand. Aging studies will be conducted to determine formulation component stability, including particle agglomeration and settling, and used to determine any adverse effects on coating performance. If necessary, particle re-dispersion procedures will be developed. Reliable metrology will be used to evaluate success and failure criteria for coatings applied to sand abraded and scratched transparent armor under at least three damage conditions (e.g., minor, medium, and heavy). Best coating application practices will be determined on standard issue goggles (e.g., spraying, dipping, rolling). Durability testing (abrasion resistance, cracking, peeling, flake off) on the repaired surfaces of 50 standard issue goggles will be conducted so that a cost/benefit analysis can be performed by the Army. The formulation should be easily scaleable so that manufacture can be done either by the small business or through a toll processor. The coating should be non-toxic, non-flammable, easily applied, meet existing United States VOC manufacturing regulations, and should not require expensive or difficult to operate equipment.

PHASE III: The technology developed as a result to this research will find applicability to both DoD and civilian applications including coatings for eyeglasses, goggles, lenses (e.g., watch, camera, binoculars), headlights, and windows.

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KEYWORDS: Abrasion, Coatings, Composites, Optical, Particles, Repair, Scratch, Surfaces

A06-081 TITLE: Efficient and Novel Algorithms for RADAR Systems with Phased Array Antennas

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The purpose of this SBIR topic is to solicit developments of efficient and novel algorithms for signal extraction/detection and object recognition in RADAR systems with phased array antennas. The algorithms developed should have the capability for handling fast changing nonlinear and cluttered environments.

DESCRIPTION: Efficient methods of signal extraction/detection and object recognition in Radars with phased array antennas (RPAA) in complex cluttered environment and under prior uncertainty include adaptive spatial and spatial-temporal processing. Adaptive spatial filtering includes weighted accumulation of signals at outputs of channels in a multi-channel system. The vector of weights is computed based on the estimates of the clutter covariance matrix. A conventional approach involves the following three-stage procedure:
1. Estimation of the clutter covariance matrix based on a training sample in passive mode;
2. Setting an adaptive threshold, also based on the training data;
3. Adaptive processing of data in active mode using previous two steps (in particular, adaptive thresholding to limit a false alarm rate).

This standard approach is efficient in cases where clutter does not change or changes slowly in time, so that the estimates obtained from steps 1 and 2 are accurate enough for the third step. However, the drawback of this approach is that weighted coefficients used for target detection (thresholding) and recognition are computed based on the training sample, while detection and recognition are performed based on the testing sample in active mode. In rapidly changing environment when clutter is nonstationary, the performance of this procedure degrades dramatically.

Therefore, the development of a novel approach that overcomes shortcomings of the conventional method is a challenging problem. Moreover, the corresponding new algorithms should be efficient not only for nonstationary Gaussian clutter, but also for non-Gaussian clutter. New methods have to perform adaptive tuning (in particular, computing of weighted coefficients) simultaneously with target detection and recognition. New methods should not use passive training data to form adaptive thresholds for false alarm stabilization and to compute vectors of weights for adaptive weighted processing for ATR (i.e., these functions should be performed as a one-stage adaptive procedure that uses only testing sample).

Specific requirements to new methods:
1. No pre-classified training data sets that do not contain targets should be used for tuning.
2. No Gaussian assumption on the clutter distribution should be used.

3. Algorithms should be efficient when the sample size (in time) bigger than a number of clutter sources in space, but not the number of phased array channels. Otherwise, computational complexity will become an issue.
4. Algorithms should guarantee super-resolution properties in (a) space; (b) range; (c) frequency (speed).

The purpose of this topic is to call for involvement of the private sector in these studies that will enhance the development of ATR (automatic target recognition) systems for the United States Army, Air Force, and Navy. In particular, the Army agencies such as Aviation and Missile Command and Space and Missile Defense Command will be among the beneficiaries of this research. The mathematical tools and technique needed for the research include new theory and algorithms of spatial-temporal nonlinear filtering. Mathematical developments in this area can also be applied to commercial radar systems for airlines and weather forecasting. It is proposed that the program be carried out in the following three phases.

PHASE I: Phase I of this SBIR project shall focus on feasibility study of: 1) non-usage of pre-classified training data sets for turning; and 2) deletion of Gaussian assumption on clutter distribution. The results of the Phase I research shall be documented in monthly progress reports and the final report.

PHASE II: In Phase II, we suggest that the following issues be investigated:
1) Development of spatial-temporal nonlinear filtering and/or other theory and methodologies that are applicable to the RADAR systems with phased array antennas.
2) Development of the computational algorithms for the theory and methodologies mentioned above. The results of the research shall be delivered in the form of written reports and demonstrations of the efficiency of the algorithms.

PHASE III: The research and development of efficient and novel algorithms for RADAR systems for commercial flights and weather forecasting. Computer codes (both source and executable codes) for the algorithms shall be delivered for further testing.

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KEYWORDS: spatial-temporal nonlinear filtering algorithms, radar systems, phased array antennas, signal detection, target recognition

A06-082 TITLE: <u>Multifunctional Erosion Resistant Coatings for Turbine Engine Components</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop innovative, advanced multifunctional erosion resistant ceramic coating concepts to significantly improve the erosion related degradations of compressor and turbine hot-section components in harsh sand ingestion, and/or combustion gas environments.

DESCRIPTION: The advanced propulsion engines for Future Combat Systems (FCS) and Joint Heavy Lift helicopters may be designed by utilizing high strength and lightweight metallic and ceramic components to meet engine high efficiency, high power density, compactness, and low emission goals. Advanced erosion resistant coatings will play a crucial role in the engine systems by providing vital erosion, corrosion and thermal protections for engine components in the harsh sand ingestion, erosive and/or combustion gas environments.

This SBIR solicitation seeks innovative ceramic erosion resistant coating concepts for turbine engine compressor blades and vanes to meet future engine performance goals. Thin film configurations with combined high hardness and toughness are required for this compressor erosion coating application. In addition, advanced erosion and corrosion resistant thermal and environmental barrier coating concepts for metallic superalloy and Si-based ceramic turbine hot-section components will also be of great interest. In particular, novel ceramic barrier coatings with significantly reduced sand particulate erosion and molten sand interaction related degradations under thermal cycling will be considered. The SBIR will emphasize advanced coating compositions, architectures and processing techniques to significantly improve the coating toughness and interface adhesion, thus ultimately improving the component erosion resistance. Novel processing techniques may be developed for realizing multifunctional coating concepts in thin layer configurations with built-in or embedded erosion monitoring and damage detection sensors for turbine engine components. Innovative approaches to incorporating other coating, component and engine health diagnostic functions that can help improve the engine reliability and durability may be also developed in this SBIR effort.

PHASE I: Develop advanced erosion resistant coating material concepts for engine compressor and/or turbine applications. Demonstrate the coating feasibility and material erosion performance in laboratory tests.

PHASE II: Integrate the coating functions by multi-component alloying concepts and/or embedded sensor approaches. Demonstrate the multifunctional erosion resistant coating feasibility with potential damage detection capability for compressor and/or turbine components in engine relevant environments. Down select erosion resistant coating systems with improved performance and functionality.

PHASE III: The erosion coating technologies developed under this SBIR can be widely used in the Army and other DoD vehicle propulsion applications. The technologies can also be used for commercial propulsion and power applications including commercial aircraft engines, land-based power generation turbine engines, and diesel engines.

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KEYWORDS: Advanced propulsion technology, erosion resistant turbine compressor coatings, erosion and corrosion resistant thermal/environmental barrier coatings, multifunctional embedded sensor coatings

A06-083 TITLE: A Process to Produce High-Purity Encapsulated Particulates in Large Quantities

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To enable the Army/DOD/Industry to procure a new class of materials and a new raw material source, by the development of a process to encapsulate particulates in large quantities. These particulates can subsequently be used to produce bulk materials/coatings/components with specific engineered properties that can significantly increase the lethality of various weapons systems, such as bullets, rockets, shape charges and mortars.

DESCRIPTION: Recent achievements in the consolidation of metallic and/or ceramic particulates, in addition to the need to control the chemistry of inorganic and organic coatings and bulk materials, has created the need to produce a new raw material source in the form of encapsulated particulates. The ability to uniformly apply an element onto a micron or sub-micron particulate will allow for the development of a new class of materials that can be used to engineer coatings and/or bulk materials with greater precision. The proposal calls for the production of encapsulated particulates, having diameters in the range of 1-10 um, that have a high-purity, uniform coating over the entire surface area of the particulate. These size particulates, which fall into Geldart's Class C category of particulate material [1], often have high aspect ratios and cause particular problems when attempts are made to consolidate them, since they tend to agglomerate and are difficult to handle and process. The ability to control the thickness of the coating is a requirement, as well as the ability to economically produce at high-volume production rates (thousands of pounds). These materials could then be used by the Army/DOD/Indusrty to produce weapons with greater lethality and would be able to be used to solve a variety of problems that have plagued the US Armed forces and the commercial sector for years, such as lead-based munitions[2]. The development of this technology will also provide for significant advances in combustion and propulsion science, resulting in the production of munitions with greater scaled lethality.

PHASE I: Develop and demonstrate the use of a process to uniformly coat two different particles with a specific element to a specific wt% as described:
1. Aluminum particles having a diameter of 10-20um are to be coated with a uniform layer of Nickel resulting in an Aluminum coated particle having a composition of 70%Ni-30%Al wt%.
2. Tungsten particles having a diameter of .5-1um are to be coated with a uniform layer of Copper resulting in a Tungsten coated particle having a composition of 80%W-20%Cu wt%.

The proposer would be expected to produce at least 10 pounds of powder and if successful demonstrate a process for producing encapsulated particulates meeting these requirements. The proposer should address the necessary process parameters required to scale-up to produce high-volume quantities.

PHASE II: Building on the successful results of Phase I, develop the process for producing large quantities of encapsulated powder and expand the technology to enable the production of other types of encapsulated particulates including ceramic and nano-size powders (.5-1um). A goal of this program is the ability of the process to produce large quantities (batches of 50-100lbs) with the same or improved material properties from Phase I. 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 production of 500lbs of Aluminum coated particles having a composition of 70%Ni-30%Al wt% at the end of the first year of the Phase II effort. This powder 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 develop the process parameters, demonstrate production capability and deliver three additional prototype powders, to ARL, for evaluation.

PHASE III: The procedures developed during the performance of this SBIR for producing encapsulated particulates will then be scaled and applied to other Army applications (various caliber munitions and mortar systems, shape charges and mortars).

The development of the technology which allows for the production of high-purity encapsulated powders will enable a new raw material source that can be used by the powder metallurgy producers, thermal spray industry and other particulate materials industries to make advancements in the production of materials that could not otherwise be produced, including nano-size bulk materials and coatings for use in the electronics, aerospace, automobile and petrochemical industries, for the production of conductive-high temperature resistant coatings, corrosion and wear resistant coatings, cutting tools, abrasives and heat exchangers.

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KEYWORDS: Encapsulated Particulates, Metal Coated Particles, Metal Powder, Powder

A06-084 TITLE: Reliable Biometrics Data Quality Measure for Multi-modality Biometrics Fusion

TECHNOLOGY AREAS: Information Systems, Biomedical, Human Systems

ACQUISITION PROGRAM: PEO Enterprise Information Systems

OBJECTIVE: The objective of this project is to develop and implement reliable biometrics data quality measures for multi-modality biometrics systems.

DESCRIPTION: Biometrics data quality is one of the variables that has the largest effect on biometric system accuracy and is the major cause of high false reject rates (FRR) and failure to enroll (FTE) rates [1][2][3]. Recent studies have revealed that this strong dependence of authentication performance on biometrics data quality makes many critical biometric systems vulnerable to exploitation [4]. Within a high-quality multi-modality biometrics system, two or more forms of biometrics data are combined to perform human identification or authentication. Knowledge of biometrics data quality will allow such a system to carry out multi-modality data fusion intelligently. For example, using data quality-based modality, specific weights can be assigned so that poor quality biometric data will have less influence on final decision.

There have been recent works in the area of biometrics data quality analysis [5-8]. However, there are no or very few implementations of multi-modal biometric data analysis functions in current commercial systems although such data quality assessment has been deemed as a critical component for robust biometrics authentication.

To achieve the goal of this project, a well-performing and high confidence biometrics data quality assessment system must advance the state of the art of in the following areas:
1. Better quality assessment methods:
New techniques for assessing data quality for biometric systems (both single and multi-modal) are essential to improve fusion accuracy and authentication performance. A thorough comparison study is necessary to learn the advantages and disadvantages of various proposed methods. Further, new algorithms/methods need to be developed to perform reliable data quality assessment. Such algorithms/methods must be able to generate quantitative data quality measures such that they can be used as an input to the multi-modality fusion system.

2. Performance improvement for single and multi-modal biometric systems:
New data quality techniques must advance the accuracy of authentication performance. A reliable and effective data quality assessment algorithm must be developed to analyze, quantify, and calibrate the performance of a specific biometrics system. The ability to benchmark system performance quantitatively through biometrics data quality analysis will allow us to design and develop more accurate biometrics systems. Further, it offers an opportunity to develop data processing schemes to correct low quality data.

PHASE I:
a. Conduct a literature survey on proposed methods and make comparisons.
b. Research and develop biometrics data quality measure techniques that can evaluate the accuracy of single or multi-modality biometrics system. The biometrics data of interests may include (but not limited to) fingerprint, facial images, iris image, hand geometry, etc. Based on data quality measurement, develop data processing schemes that can enhance data quality/accuracy through techniques such as filtering, restoration, or re-sampling.
c. Demonstrate that the proposed method can improve accuracy on biometrics based authentication systems through lab experiments

PHASE II:
a. Develop a generic framework that can perform biometrics data quality assessment for various biometric traits and performance quality-based multi-biometric fusion.
b. Develop a full implementation of the assessment algorithm and make it available for commercialization.
c. Demonstrate that the proposed method can improve system accuracy of multimodal biometric systems through field trials.

PHASE III: Plan and perform full commercialization of the developed technology. The biometrics data quality measurement tool can be licensed to biometrics vendors or be implemented as a stand-alone data analysis tool that can be run on generic computers such as a Window-based systems. Hardware based implementation is also highly desirable. The hardware based implementation will allow the data quality evaluation carried out in real-time on a large amount of data. The biometrics data quality measurement tool should be an integral part of a multi-modal biometrics system which combines different types of biometrics data (such as fingerprint plus facial image) to achieve accurate verification or identification of human subject. A biometrics verification and identification system with a high accuracy is of high importance to military field operations as well as to civilian applications such as border control or trusted traveler program.

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KEYWORDS: Biometrics Data Analysis, data quality measure, biometrics data fusion

A06-085 TITLE: Real-Time Tracking of Multiple Entities Within a Complex Joint Urban Environment

TECHNOLOGY AREAS: Ground/Sea Vehicles, Battlespace, Human Systems

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 a tracking system that can provide local positioning within a complex Urban environment, to include positioning in and around buildings of all types.

DESCRIPTION: The need to test the Warfighter as a system of systems continues to grow as their complex roles evolve with the technical advances being introduced through Future Combat Systems (FCS) and other military programs. Due to the ongoing conflict, there is much demand on training and testing of soldiers in a Military

Operations on Urban Terrain (MOUT) or Urban environment. To adequately test soldiers in such environments, it is critical to know where they are located at all times, including inside of buildings. Knowing where the soldier is located within a test environment will provide valuable information about the context of the soldier's surroundings, which can be a necessary component of determining the soldier's Situational Awareness (SA). Tracking technology can also be linked with Laser Engagement Systems (LES) to provide higher fidelity in force-on-force actions. It can also be used to supplement virtual and constructive test environments. The state of the art in this technology area consists of systems based on different technologies, such as Ultra Wide-Band (UWB), Radio Frequency Identification (RFID) and Inertial Measurement Units (IMU). Current tracking technologies do not meet all of the requirements for tracking soldiers within the constrained and harsh environments definitive of MOUT and Urban test sites. Many of these systems lack the power to transmit signals over large distances and the ability to transmit through walls and objects (specifically metal). There is also a limit in current tracking technology on how many people can be tracked at once and at what frequencies. There is a great need to establish a tracking technology with high accuracy and update rates, and the ability to track a large sum of individuals within locations of various dimensions. There is also a need for this technology to be able to withstand the harsh and noisy test and training sites. With such a system, the capability will exist to track soldiers accurately within tight groupings and small spaces. This technology will provide the means to achieve a more accurate classification of the soldier's SA. It would also provide the capability to automate some of the testing environment if the tracking data is used as feedback to control certain test instrumentation, such as cameras, targets, and audio sounds, and possibly even pyrotechnics. This tracking technology will find many uses within the Developmental and Operational Test Commands along with the training communities such as the Fort Benning McKenna MOUT site. We need a small business to perform Research and Development (R&D) with respect to tracking within a complex Urban environment and deliver a feasibility study followed up with a prototype.

PHASE I: The focus of Phase I will be to identify soldier tracking requirements within an Urban environment and identify the technologies that are most capable of meeting those requirements. This effort will also result in the determination of appropriate tracking hardware and software for visualization of the tracking data.

PHASE II: The Phase II effort will result in the development of a working hardware prototype and software solution for tracking data visualization. The prototype will demonstrate the capability to accurately track soldiers within an Urban/test environment and provide a software visualization package that can be integrated into a test or training site.

PHASE III: The proposed technology will have a high payoff throughout the DoD testing and training communities. The proposed instrumentation will be applicable to any testing and training site that is involved with soldier operations in an Urban environment. Projected use case beyond Research, Development, Test and Evaluation (RDT&E) include use in hospitals for patient and asset tracking, and tracking of military logistics within an operational environment.

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KEYWORDS: tracking, positioning, military operations in urban terrain (MOUT), situational awareness

A06-086 TITLE: Multiplex Data Bus Controller/Translator

TECHNOLOGY AREAS: Air Platform, Information Systems, Electronics

OBJECTIVE: To have small business perform R & D with respect to aircraft bus controllers and deliver a feasibility study followed by a prototype Multiplex Data Bus Controller, Translator and Transmitter (MDBCTT).

DESCRIPTION: Aircraft systems have a requirement to communicate with one another during operation. Modern aircraft accomplish this with multiplex data bus systems.

The state of the art in data bus technology allows the data buses to act as conduits for data streams from/to aircraft components. Aircraft systems data may be gathered from the data buses and, in some cases, communications data has been input to aircraft radios. Stimulation of aircraft systems such as sensor target detection or aircraft engine parameters require multiple bus stimulation input.

Current technolgy precludes stimulation of multiple aircraft systems making the aircraft believe that it is flying while it is in a controlled environment in a hanger.

The technology to externally input flight data through the data buses simply does not exist.

ATTC realized that if stimuli could be input through the aircraft multiplex bus to aircraft systems and sub –systems, control of those systems could be gained.

The ability gain control and to command aircraft systems in a laboratory environment, will allow the testers to simulate system response to variable aircraft and system states without the inherent risk and cost of open air flight testing.

The ability to input bus data is a requirement of the U.S. Army Aviation Technical Test Center System Test and Integration Laboratory (STIL) and Crew Station Interface (CSI) being developed by the Program Executive Office for Simulation, Training and Instrumentation (PEO STRI).

A MDBCTT will provide an interface between the STIL/ CSI, and data bus controlled aircraft to permit realistic aircraft-in-the-loop simulation of system and sub-system operation. With the STIL connected to the aircraft through the MDBCTT the aircraft crew controls the aircraft systems by manipulating system and aircraft controls in response to STIL inputs. The MDBCTT will receive and translate the bus traffic into open architecture computer language. The signal will be sent to the STIL, test cells or simulation devices where it will be used to emulate, stimulate, or simulate aircraft component(s) being tested or developed. The MDBCTT will be capable of receiving computer generated input from the STIL, CSI, test cells or simulators, converting the signals to bus traffic and either providing the appropriate response or directing the appropriate action of the aircraft system(s). The interface must not interfere with the subsequent airworthiness of the aircraft. The interface must not damage the aircraft, components or sub components of the aircraft. The interface should be capable of integrating a majority, if not all, of the aircraft systems.

REQUIREMENTS:
a. Physical: Requirements are for computer software and hardware necessary to perform as a data bus controller and to translate bus traffic to an open architecture computer language allowing external display of all aircraft systems information.

b. Aircraft Interface: The MDBCTT should interface with the aircraft using open architecture software and without extensive instrumentation.

c. Realistic Pilot Feedback: Feedback to the pilot will be provided by translating emulated, stimulated or simulated message traffic to data bus traffic and directing, via the MDBCTT, the appropriate response in aircraft systems and displays. Feedback to the pilots may include flight controls, flight instruments and displays, and system monitoring displays.

d. Visual Displays: Bus data traffic received and translated by the MDBCTT may be used to drive out-the-window (OTW) displays or on board aircraft sensors (i.e. Pilot Night Vision Sensor). However, no specific requirements exist for the MDBCTT to drive the displays. Digital image traffic may be sent via the MDBCTT to the aircraft data bus to drive the on board aircraft visual displays.

e. Setup/Tear Down: The MDBCTT should require no more than one day to set up or to tear down.

PHASE I: Determine feasibility and develop system design that includes specification of the off-aircraft Bus Controller/Translator for one of the Army’s advanced aircraft.

PHASE II: Develop an operational prototype MDBCTT for the advance Army aircraft equipped with a 1553 data bus. The prototype will be installed at the Aviation Technical Test Center, Fort Rucker, AL.

PHASE III: The MDBCTT has numerous possibilities for use in conjunction with a broad range of military and civilian activities where there is a need to interface with aircraft or ground vehicle data bus traffic.

a. Military activities include, when used in conjunction with simulation hardware/software: Training and currency requirements; use by forward deployed units for realistic mission rehearsals; use by units not collocated with fixed base simulators.

b. Civilian applications include: Fixed base airport operations support to private/general aviation aircraft for special use/high risk operations training and mission rehearsals (oil rigs, ships, logging operations); commercial airlines training.

KEYWORDS: Multiples Data Bus Controller Translator and Transmitter, MDBCTT,bus controller

A06-087 TITLE: Improved Web-Based Mapping

TECHNOLOGY AREAS: Information Systems, Battlespace

OBJECTIVE: Research available commercial web-based mapping tools to find and leverage for use in military web-based mapping applications. Develop an Improved Web-Based Mapping (IWM) application server product that provides thin client map access in a web browser but with fast response times.

DESCRIPTION: NEBC (Network Enabled Battle Command) is an Army Technology Objective (ATO) in the Communications-Electronics Research, Development and Engineering Center (CERDEC), the Command and Control Directorate (C2D) focused developing C2 (Command and Control) mission planning and execution monitoring services. C2 Service clients will come in many varieties, but the main difference is thin versus thick. Thick clients are applications that require heavy install processes and take up large amounts of hard drive space. They tend to run faster than thin clients but are available to a smaller set of users. Thin clients require little or no install processes and take up almost no hard drive space. While thin clients tend to run slower than thick clients they are available to a larger group of users. Thin clients could be something as simple as a web browser.

There exists a need to display mapping information over a network in a timely manner. Current solutions (ArcIMS, JointWebCOP, etc…) work adequately, but there exists new emerging solutions (Google Maps, MSN Virtual Earth) that seem to work much more efficiently and display mapping information over a thin client as if it was a thick application. By utilizing technology like AJAX (Asynchronous JavaScript and XML) the user can view information over a web browser with the response time close to that of a local application (thick client). The user can pan and zoom the map with such speed that it appears to be running locally with no delays for the communication to the server.

The goal of this SBIR is to create an IWM web server application that allows commanders and other military and edge users to view mapping and plan information over a web browser in an extremely fast manner. Loading and wait times should be virtually non-existant. Research of existing commercial tools will have to be completed to determine what can be leveraged and what has to be created. In addition to displaying mapping products like DTED (Digital Terrain Elevation Data), the IWM should provide an API (Application Programming Interface) that would allow other data providers to incorporate their information into the map (e.g. weather, intelligence, logistics). Effectively this would create a combined mapping product that merges all different types of information into one uniform picture that can be provided to the user. Examples of this type of merging can be seen at HousingMaps, where real estate data is overlaid on mapping information coming from GoogleMaps. The end result is that the user is presented with data from multiple sources but integrated into one picture.

PHASE I: Research commercially available thin client technologies (i.e., AJAX). Explore how these components could work with available military mapping technology and data elements. Any solution must work in concert with the C/JMTK (Commercial Joint Mapping Toolkit) as it is the standard for generating military maps and symbology. Also, this solution must be capable of allowing multiple providers to incorporate data into the map.

PHASE II: Build an IWM that would reside on a web server and act as a map/data displayer to any thin clients. The IWM will also provide an API such that any other data provider could incorporate its information into the map.

PHASE III: The final product and API specification could be commercially licensed to mapping companies like ESRI (Environmental Systems Research Institute) or included as part of the C/JMTK. Specific commercial applications include the creation of a fast web-based weather map viewer or dynamically updating traffic and congestion maps.

For military use, the IWM could be included as an enhancement to the existing PM GCCS-A (Global Command and Control System - Army) product JWC (JointWebCOP).

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KEYWORDS: mapping, ajax, cjmtk, thin client, web services

A06-088 TITLE: Automated World-View Construction for a Multi-Modal Mobile Mounted Sensor Suite

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To develop algorithms for the automatic fusion and registration of multi-modal sensor data from multiple sensors mounted on a swiftly moving scout vehicle—for the purpose of real-time analysis and post-processing. The goal is to quickly acquire an accurate and integrated model of the vehicle's environment so as to identify threats, for example improvised explosive devices (IEDs), in order to enable target recognition and change detection processing. The algorithms will integrate state-of-the-art advances in sensor fusion, image registration, tracking, and global positioning system (GPS) analysis—enhancing situation assessment while minimizing exposure to enemy identification and attack. The algorithms will specifically address overcoming GPS error to provide an accurately geo-registered world-view in order to permit later revisiting of suspicious objects.

DESCRIPTION: The importance of rapid and accurate scouting capability cannot be overemphasized. It is vital that such efforts are as inconspicuous as possible while collecting reliable information that can allow reaction to immediate threats and pinpoint locations for later closer inspection. In addition, it is important to utilize the advanced capabilities of multi-modal sensor suites for inspection and detection. These sensor types include, but are not limited to, high resolution visible wavelength cameras, infrared and near-infrared wavelength sensors, magnetometers, and GPS devices (respondents should be prepared to work with Army to expand sensor configurations and may suggest expansions in their proposals). However, rapid migration through the environment combined with multiple sensor input often causes unacceptable error. Specifically GPS information is often imprecise to the point of making extremely accurate fusion and registration impossible. The research goal is to optimally overcome sources of registration error while maintaining speed of movement (40-75 kph). The innovation here over previous work is that as yet, no military system effectively provides such rapid, very high accuracy, multi-sensor scouting capability.

PHASE I: (Respondents are not required to develop hardware for program.) Will investigate, enhance, combine, and create algorithms and methodologies for automatic fusion and registration of multi-modal sensor data. Will provide specific and detailed testing plan focused on proving applicability. Will conduct limited tests.

PHASE II: Will conduct full system tests for the automatic fusion and registration of multi-modal sensor data. Will demonstrate functioning and utilizable prototype system. System will perform successful registration of data from (but not limited to) sensor types listed in project description above.

PHASE III: Commercialization of technology would involve all types of scouting and mapping, including surveying operations and border control. Applications exist wherever a multi-sensor multi-modal collection of data must be integrated and indexed. Additionally, this project could lead to advanced applications in automated driving and flying.

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KEYWORDS: sensor fusion, tracking, image registration

A06-089 TITLE: Helmet Antenna System

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop a 225 MHz to 2500 MHz helmet antenna system and an innovative antenna to radio connection.

DESCRIPTION: The helmet is an ideal location for Radio Frequency (RF) communication antennas given that it is the highest point on the soldier. Presently, there are a number of concerns in the use of a helmet antenna. The major concerns are size and weight of the antenna, the antenna connection to the radio (radio is normally carried at the torso of the solider), health issues associated with RF radiation absorbed by human tissue, and Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) of the helmet antenna with other electronic equipment such as headset, display, and weapon targeting and acquisition.

The Future Force Warrior (FFW) Advanced Technology Demonstration (ATD) had made the assessment that helmet antenna technology represents high risk for the FFW ATD and decided on a body worn antenna solution without any helmet antenna components. The objective of this SBIR effort is to investigate solutions to mitigate the technical concerns to enable helmet antenna to be a practical antenna solution for the future soldier combat system beyond FFW ATD.

A soldier combat system includes all the soldier’s wearable gears, weapons, communication equipments, and sustainment supplies. A body worn antenna that is at a lower height has the potential of interference with other gear hanging off the soldier. There are more system configuration variations with the lower (that is below the neck) portion of the soldier combat system, dependent on weapons and supplies the soldier carries, and the soldier's fighting position, such as in a fox hole, or a prone position. The helmet antenna has the advantage being on a rigid, stable platform located high on the soldier combat system.

To address the concerns of size and weight of antenna, cumbersome and inflexible antenna connection to the radio, an integrated solution for a helmet antenna and antenna to radio interconnect system of 225 MHz to 2500 MHz, 1 watt, and less than 4 oz is needed. The RF radiation absorbed by human tissue, and Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) of the helmet antenna with other electronic equipment such as headset, display, computer and weapon targeting and acquisition system also need to be addressed. Existing antenna to radio connection solutions are too large and inflexible or flexible and not rugged. Soldiers require a connection solution that will not impede their movements, that is light and rugged and does not add to the EMI/EMC issue of the soldier combat system.

The specific absorption rate (SAR) measurement referenced will use industry and IEEE test standards that use specially designed manikin and measurement equipment. Human and/or animal test subjects will not be used.

PHASE I: Design the helmet antenna and antenna to radio connection accounting for EMI/EMC and health issues.

PHASE II: Using the design from Phase I, develop a helmet antenna and connection device system.

PHASE III: The developed innovative connection device is primarily for helmet antenna application, there are many other electronic equipment that need to be interconnected in the soldier combat system, and any cables reduction will improve the performance of the system, such as ergonomics (soldier movements, avoid entanglement with foliage, quick set-up), maintenance, reliability, and cost.

Military applications include various military platforms, Unmanned Aerial Vehicles (UAV), and the FCS Program. Commercially, the aviation, automotive, and marine industries with an ever greater number of wireless systems would be interested in technology for improved and simplified antenna systems.

REFERENCES:
1) IEEE/ANSI C95.1. Institute of Electrical and Electronics Engineers (1999): IEEE/ANSI Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, New York, NY.
2) Leonard, N. B., K. R. Foster, and T. W. Athey. "Thermal Properties of Tissue Equivalent Phantom Materials," IEEE Transaction on Biomedical Engineering, Vol. BME-31, No. 7. July 1984, 533-536.
3) Ziriax, J.M., Hurt, W., Cox, D., Marchello, D., and D'Andrea, J. "Assessment of Potential Radiation Hazard from the COMWIN vest antenna." 2003. Technical Report NHRC-DET-DEBL-TR-2003. Naval Health Research Center Detachment, Directed Energy Bioeffects Laboratory, Brooks City-Base,Texas.

KEYWORDS: helmet, antenna, connection, EMI, EMC, communication, SAR

A06-090 TITLE: Detection and Neutralization of Improvised Explosive Devices

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: To develop sensors capable of detecting and identifying improvised explosive devices (IED) and landmines; or to develop devices to precisely neutralize landmines and IEDs at large standoff distances. For landmine and IED neutralization, the objective shall be to investigate innovative technical concepts for the neutralization of buried and non-buried, or obscured, landmines and IEDs.

DESCRIPTION: The Countermine Technology Branch of the Science and Technology Division of the Night Vision and Electronic Sensors Directorate has an interest in technologies for detection and neutralization of landmines and improvised explosive devices. The explosive may be TNT, RDX, HMX, or nitro. The sensor must either identify the presence of an explosive, the explosive detonator or uniquely identify commonly used metal containers. There are three cases of interest.

For case one the sensor will confirm the presence of a landmine or an IED that is detected by other means. The amount of explosive may be from 300 gm to 20 kg. The minimum standoff distance is 30 cm. and the minimum identification time is 60 seconds. Longer standoff distances and shorter times are desirable. The larger items in this class are commonly mortar or artillery shells. The explosive may be encased in a steel or other metal container of up to 4 mm in thickness. In addition the larger explosive devices explosive may be buried under 12 cm of rocks or soil. The generic detection of a piece of metal without identification as an IED is not of interest for this case.

For the second case the sensor will detect vehicle borne threats. The amount of explosive would be from 150 to 400 kg. The time to scan an average sized car must be less than 60 sec. The vehicle would be unoccupied. The ability to scan a moving occupied vehicle would be of even greater interest.

The third case involves the detection of a landmine or an IED at standoff distances of 20 m or more. For this case the IED is a mortar or artillery shell and may be covered by rocks or other material. The detection of a large obscured metallic object at these distances is of interest for this case. The sensor must scan a 4m wide path and be capable of moving at speeds greater than 3 kph.

If neutralization technical solutions are proposed, the innovative research concept must provide standoff precision neutralization approaches that can neutralize individual buried and surface landmines and IEDs, and can be mounted on a manned (or unmanned) Future Combat Systems (FCS) vehicle. The technical solutions shall enable the FCS vehicle to neutralize mines, IEDs, and off-route mines in all mounted trafficable terrain at standoff distances and at objective rates-of-advance with a minimum of logistics burden. The neutralization concept shall support standoff precision mine neutralization of antitank mines, IEDs, and off-route mines at distances of up to 250 meters in front of the host vehicle and at a system rate-of-advance of 25 kph. The technology solution shall have a probability of kill (Pk) greater than 90 %. The neutralization time shall be less than 15 minutes, with 2 minutes desired.

PHASE I: This proof of feasibility phase will focus on laboratory and limited field investigation of the landmine/IED detection or neutralization technique(s) as a potential candidate for application in a tactical system. The sensitivity of the mine detection technique to discriminate landmines and IEDs from clutter objects will be determined. Phase I will include a demonstration to experimentally confirm the lab results and analyses by utilizing a variety of appropriate landmines and IEDs.

PHASE II: The purpose of this phase is to design and fabricate a brassboard data acquisition system and to use this brassboard system to experimentally confirm the detection or neutralization capability under varied conditions and undergo extensive testing at Army facilities. Practical application of the technology, including proposed host-platform integration, will be investigated. Estimates, with supporting data, will be made of size, weight, power requirements, speed, Pd, false alarm rate and positional accuracy. Even at this stage all specifications such as detection or neutralization 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.

REFERENCES: A host of information regarding the current state-of-the-art in mine detection can be obtained through the following conferences: SPIE Defense and Security Symposium (Detection and Remediation Technologies for Mine and Minelike Targets Session) in Orlando, FL; Mine Warfare Conference; and UXO Detection and Remediation Conference.

KEYWORDS: Explosives detection, IED detection, IED neutralization, landmine detection, landmine neutralization

A06-091 TITLE: Lithium-Air Hybrid for Soldier, Sensor and Unmanned Aerial Vehicle (UAV) Power

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a high energy/high power lithium-air hybrid system to provide power to dismounted soldier's electronics suite. Proposed Lithium-air hybrid system needs to be 12V, 1000W-hrs/kg at 100W for extended missions in the battlefield.

In addition to supporting the dismounted system, the proposed lithium-air hybrid system would also support unattended sensors in the battle space for prolonged periods of time.

DESCRIPTION: Soldiers of the 21st century are more reliant on technologies to win the war in the battlefield. Due to the increase in technological advances, portable power sources have been stretched to the point where advanced technologies to help the soldiers cannot be supported due the lack of power.

New battery chemistries need to be developed to support increased power demands of the future force warrior. The highest specific energy capacity potential is offered through metal-air batteries (specifically lithium-air battery). The theoretical energy capacity for a lithium-air battery is ~ 11kW-hr/kg. The drawback is that it does not offer high power. To solve this problem, a hybrid system, consisting of an integrated high energy battery and high power battery would be the ideal system to support the future power load for the dismounted soldier.

The proposed Lithium-air hybrid system would also support unattended ground sensors for extended periods of time in the battlefield. These sensors monitor activities in the battlefield and send signals if enemies are detected. It is very important that the power source is reliable in any environmental condition for the soldiers to hear, see and strike first.

PHASE I: Identify/specify lithium-air cells technology use in this system of delivering 2000W-hrs/kg and any high specific power battery able to deliver 100W to complement lithium-air battery. All class of lithium-air batteries, aqueous, non-aqueous, solid state will be considered if it falls within the guideline of performance and safety. All chemistries for high power batteries will also be considered, lithium-ion, nickel metal batteries and etc..., if the total performance of the lithium-air hybrid system is greater than 1000W-hrs/kg.

PHASE II: Component fabrication/integration of Lithium-air hybrid system/testing: the subcomponent from Phase I will be fabricated and integrated into one hybrid system for testing. The system will be tested for performance and safety. Continue efforts to improve subcomponents to meet the goal of 1000W-hr/kg at 100W for the lithium-air hybrid system. Develop business case analysis showing how lithium-air hybrid would benefit the Army/DOD. Develop a marketing strategy for launching into a commercial market segment.

PHASE III: The results and effort from Phase II will afford the contractor the capability to provide the Government and industry a high energy/ high power system needed to support power hungry electronic suites for the future. Potential applications for the Army is powering the electronic suite for the dismounted soldier (e.g., weapon sight, radio, biosensors, GPS and other technologies as it evolves). Use the hybrid system to power unattended ground sensors to detect enemies.

Potential commercial application related to area in which high energy/high power is required for extended periods for surveillance.

REFERENCES:
1) Handbook of Batteries Third Edition, Linden and Reddy, McGraw-Hill, 2002.

KEYWORDS: Lithium-Air Hybrid, Metal-Air Hybrid, High capacity High energy battery

A06-092 TITLE: Low-Power/Low-Cost Global Positioning System (GPS) Receiver Card

TECHNOLOGY AREAS: Information Systems, 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: To develop a low cost, low power military Global Positioning System (GPS) Precise Positioning Service (PPS) receiver card for embedding in handheld applications.

DESCRIPTION: The vision of Army Force Transformation operations are embodied in programs such as Future Combat System (FCS) and Future Force Warrior (FFW) that emphasize a lightweight, highly mobile force with information superiority used as a force multiplier. The fundamental element of information superiority, forming the foundation of Battle Command, is position and navigation data. A key enabler of this vision is a position/navigation and tracking system that is capable of providing its own platform navigation, as well as providing for position distribution among the various force elements (i.e., dismounts, sensors, fires) for virtually all military functions.

The objective of the Army CERDEC Research and Development program, Advanced Pos/Nav and Tracking the Future Force (APNTFF) is to develop affordable, reliable and accurate sources of position, orientation, and movement information for soldiers and other platforms to support operations and training in urban and other complex environments.

Lessons learned from Operation Enduring Freedom and Operation Iraqi Freedom have indicated a need for low cost GPS receivers for nearly every soldier on the battlefield that would increase the demand for batteries. The AN/PSN-13 Defense Advanced GPS Receiver requires one watt electrical power and operates in continuous mode for 16.5 hours on four AA size lithium iron disulfide batteries. It is expected that the new M-Code signal will increase the power required. This topic will employ advanced low power optimization hardware and processing techniques to develop a prototype GPS receiver technology that is optimized for military handheld and PDA applications that provides a highly robust positioning capability.

The low-power, low-cost military GPS receiver card will need to acquire and track C/A and P(Y) GPS satellite signals on both frequencies L1 and L2 with growth to M-Code. The primary goals are to consume 40 milliwatts power to extend battery life by 25 times over current receiver technology in continuous, fix, or average operating modes. Additionally, the card weight shall be less than 70 grams (2.5 ounces) excluding batteries, volume less than 40 cc (2.5 in^3), and recurring cost shall be less than $500. A fast fix mode shall provide a single position solution within 10 seconds (5 seconds desired) of activation from a standby mode.

PHASE I: Define an approach to develop, build and test a GPS card suitable for implementation within PDA's and other COTS applications.

PHASE II: Develop, build, test, evaluate, and deliver a GPS card suitable for implementation within PDA's and other COTS applications.

PHASE III: Develop the production processes and deliver a mass producible version of a GPS card suitable for implementation within PDA's and other COTS applications.

REFERENCES:
1) A Low Power GPS Chipset with Scalable Performance and Open Architecture for Modern Location Aware Systems - M. Cavadini, P. Young, J. Brenner, F. Piazza, NemeriX SA, Institute of Navigation (ION) GPS Meeting 2003.
2) Engineering a GPS Receiver for Lowest Power Consumption; Francesco Piazza, Marco Cavadini, Alfredo Knecht and Jim Bruister; NemeriX SA, Institute of Navigation (ION) GPS Meeting 2001.
3) Low-power GPS receiver Design; Meng, T.H.; Stanford Univ., CA, USA; IEEE Signal Processing Systems, 1998.

KEYWORDS: Navigation, Global Positioning System (GPS)

A06-093 TITLE: Efficient JP-8 Burners for Soldier Portable Stirling Power Systems

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PM Mobile Electric Power

OBJECTIVE: To design, develop, and demonstrate the feasibility of an efficient JP-8 liquid fuel burner for Stirling Engine Power Systems below 250 Watts in support of the Army's need for portable power. The Army is developing man-portable (<10kg) logistically fueled stand-alone free piston Stirling engine power sources for potential use in applications such as battery recharging operations and silent direct power.

The investigation shall focus on a JP-8 burner design for an 80 Watt (electrical) free piston Stirling engine with an overall efficiency of >80%, provides 260 Watts of heat input to the engine, an operation threshold of 100 hours with 3000 hour objective goal, with reliable fast start and operation on JP-8 fuel, demonstrated over the military environmental conditions of -30C to +55C. The burner is to be designed to minimize weight, with an objective goal of less than 2 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 life of catalytic combuster materials, increase efficiency of heat recuperation, improve thermal efficiency, minimize soot and coke deposits during full and partial load operation, and minimize parasitic losses.

DESCRIPTION: The Army is developing an array of portable power technologies <250 Watts for use as stand along power generators. Currently, Stirling engine power generation has been identified as a potential technology to provide quiet portable power. Stirling engines are external combustion, thereby meeting the ARmy's "One Fuel Forward" requirement policy. A 160 Watt Stirling power system designed with dual opposed 80W free piston Stirling engines is currently under development. The design is configured to operate on propane fuel, with the goal of future design changes to allow operation on JP-8 fuel. However, limited approaches for efficient JP-8 burner designs in the <250W size are known and require specific design and material development to allow for a reliable efficient long life design suitable for military use.

Recent literature has recorded the development of small catalytic burners capable of burning JP-8 with efficiencies greater than 65% on small 35 Watt (electrical) Stirling systems. These designs have demonstrated catalytic combustor approaches suitable for providing high conversion efficiency. Improvements are required to increase the reliability and overall burner efficiency as well as scale up the design specific to meet the Army's need for the larger 80 Watt (electrical) Stirling engine used in the 160 Watt (electrical) system design.

This program is intended to produce a long-life, ruggedized burner design for use on the 160W free piston Stirling power system.

PHASE I: The investigation shall explore burner concepts, designs and materials towards development of a JP-8 burner design for an 80 Watt (electrical) free piston Stirling engine with an overall efficiency of >80%, an operation threshold of 1000 hours with 3000 hour objective goal, with reliable fast start and operation on JP-8 fuel, demonstrated over the military environmental conditions of -30C to +55C. The burner is to be designed to minimize weight, with an objective goal of less than 2 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 life of catalytic combustor materials, increase efficiency of heat recuperation, improve thermal efficiency, minimize soot and coke deposits during full and partial load operation, and minimize parasitic losses.

The effort shall demonstrate a proof of concept prototype burner components to validate the requirements.

PHASE II: Design, develop and demonstrate proof of concept integrated burner system with controls for validation with a 160 Watt (electrical) Stirling power system consisting of dual opposed 80W free piston Stirling engines. Effort will incorporate improvements identified in the Phase I effort to operational and performance limits delineated in the objective above. The proof of concept system should be able to operate through the military environmental conditions required for soldier portable power sources.

PHASE III: Commercial migration of Phase II design. Finalize development of a JP-8 burner system and controls. Modification of design to handle commercial diesel fuel. Identify target markets for applications and industry partners for production to minimize unit costs. Develop partnerships with Army project/program offices to increase rapid fielding into Future Soldier Power Systems by FY12.

Potential for commercialization: It is considered high. Both the military and commercial sector have interest in silent portable power. Burner technology to allow for the use of safe JP-8 fuel and commercial diesel fuel would allow for broad commercialization of Stirling power systems for domestic, recreational, and emergency use. Specific commercial needs for emergency first responder missions require safe reliable silent power for communications, lighting, and robotic vehicles. Similar need exists for the military and the projected design will ensure smaller, lighter components for power systems that will increase sustainability of tactical forces.

REFERENCES:
1) "Palm Power: Using Combustion at Small Scales and a Free Piston Stirling Engine to Replace Batteries", A. Gomez, S. Roychoudhury, J. Berry, J. Huth, Proceedings of IMCE2005 ASME International Mechanical Engineering Conference and Exposition, November 2005.

KEYWORDS: Stirling power system, catalytic burner, silent power

A06-094 TITLE: Models to Address Diplomatic, Information, Military, Economic (DIME) Factors for the Propagation/Evolution of Ideas Through Defined Populations

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Develop computer models to predict the propagation and evolution of ideas through civilian populations with the intent of estimating the Political, Military, Economic, Social, Information and Infrastructure (PMESII) effects of Diplomatic, Information, Military and Economic (DIME) tasks.

DESCRIPTION: Groups of people representing definable populations share ideas. These ideas take on a life of their own and spread through the population evolving and changing over time. The United States (US) might perform DIME tasks or actions on a population in the hope of achieving specific desired PMESII effects on that population. For example, the desired PMESII effect might be to have a given population feel more favorably towards the US. In order to better understand DIME tasks and their associated PMESII effects on a population it is important to begin constructing models of how ideas are adopted by populations, how ideas are propagated through populations, and how those ideas evolve in response to internal and external pressures during propagation. It has been suggested by some that ideas within populations behave much like genes and are subject to reproduction and mutation similar to genetic reproduction and mutation only at a much higher rate of speed. The term “memes” has been coined by Richard Dawkins to describe the concept.

For this SBIR, the contractor will develop a generalized computer model permitting the definition of populations with specified demographic characteristics and relationships between populations. The model will define a representation for ideas, will predict how these ideas move through the population, and will predict how ideas change as a result of actions performed on the population by outside forces and as a result of errors in transmission within the population. In addition, the contractor will provide methods for model validation with real-world populations and techniques for improving the models based on the results of the validation efforts.

PHASE I: Perform an analysis of alternatives and document the strength and weaknesses of competing applicable models. Select an approach and produce an architecture for the model to be developed in Phase II. Include in the approach an analysis of the limitations of the selected approach and a scheme for evaluating and improving the resulting Phase II model.

PHASE II: Build and demonstrate the model. The demonstration must show how populations are defined, how ideas are represented and how selected DIME-like actions coupled with the population demographics and errors in idea transmission cause the ideas the change within the population. Demonstrate the accuracy of the model's predictions with real population data.

PHASE III: The ability to accurately predict ideas moving through populations and how those ideas change as a result of actions performed on the population has widespread commercial utility for sales, advertising and political campaigns.

REFERENCES:
1) The Selfish Gene by Richard Dawkins, Oxford University Press, 1976, 2nd edition, December 1989.
2) Virus of the Mind: The New Science of the Meme by Richard Brodie, Integral Pr, September 1995.
3) Culture as Complex Adaptive System by Hokky Situngkir, http://cogprints.org/3471/.
4) Commander's Automated Decision Support Tools by Dr. John Allen
http://www.darpa.mil/ato/solicit/IBC/allen.ppt.

KEYWORDS: Memes, population models, Diplomatic, Information, Military, Economic (DIME), Political, Military, Economic, Social, Information and Infrastructure (PMESII)

A06-095 TITLE: Real-Time Three-Dimensional (3D) Visualization for On-The-Move (OTM) Applications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Develop an automated system that provides real-time Three Dimensional (3D) image capture and scene generation.

DESCRIPTION: In today's military the ability to realistically visualize the battlefield in high resolution 3D from a remote location, out of harms way is not feasible. Cameras provide a Two-Dimensional (2D) view, which does not give Commanders a sense of presence, and conventional Command and Control (C2) software provides 2D terrain maps viewed on Army Battle Command System (ABCS) workstations. Additionally, to create or model a 3D virtual environment takes weeks/months to complete, depending on the complexity of the model. The goal of this SBIR is to provide Commanders with a portable 3D visualization capability to improve a Commander's Situational Awareness (SA) while conducting C2 during On-The-Move (OTM) and dismounted operations. This will be accomplished by seamlessly fusing 3D imagery and mobile device technologies together to rapidly generate 3D terrain, vehicle, and buildings in support of virtual Integrated Battle Command Environments. Created 3D virtual environments will allow Commanders to make swift, precise command decisions through enhanced SA of the battlefield. Dismounted commanders would be able to view 3D representations of surrounding Areas of Interest (AOI) prior to embarking into hostile environments.

PHASE I: Demonstrate the feasibility of producing a demonstration of capturing and generating a scene of 3D terrain. Demonstration shall include the design how 3D images will be automatically create a generated scene. At a minimum, the analysis shall address portability issues such as: low-bandwidth remote image capture, precise 3D terrain generation, human interaction paradigms (i.e., usability, trainability), and commercially available hardware. The contractor shall also develop a test plan enabling comprehensive functional, operational, and environmental testing of the system during Phase II.

PHASE II: The contractor will perform an in-depth prototype demonstration of the Mobile 3D image capture and scene generation devices, per the proposed Phase I system design. Prototype demonstration will include mobile collaboration consistent with Army secure messaging systems, and the timeliness and accuracy of generating of 3D terrain representations including a designed human interaction paradigm. The prototype's target environments initially include stationary operations within a controlled laboratory and/or simulated Army vehicle on-the-move (i.e., ride profile on Motion Platform). Subsequently contractor will validate prototype demonstration in an operational environment.

PHASE III: The contractor will deploy the prototype system to OTM Commanders and Dismounted Soldiers during a scheduled field exercise. It is envisioned that similar systems would be desired for other agencies that are interested in interactive 3D visualization of operational data (Homeland Security /Police / Fire / Rescue / Bomb Squad), and the real estate market.

REFERENCES:

1) Mobile 3D: "link to OpenGL-ES"
2) Open 3D Standards: http://multigen.com/
3) Commercial Joint Mapping Toolkit: http://www.cjmtk.com/
4) FOC: www.tradoc.army.mil/tbpus/pams/p525-66.htm

KEYWORDS: 3D, Visualization, situational understanding, battle command, on-the-move, collaboration

A06-096 TITLE: Regenerable Sulfur Removal and Processing of Diesel and JP-8 Logistics Fuels for Fuel Cell Auxiliary Power Units

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Design, develop, demonstrate, and deliver a regenerable sulfur removal and fuel processing brass board to be used for a 1 kWe to 5 kWe logistics-fueled fuel cell auxiliary power unit (APU). The brass board must deliver an anode feed stream compatible with an investigator-identified fuel cell technology, have a maximum cold startup time of 30 minutes, have an operational life of 1000 hours, and operate on JP-8 and diesel fuels.

DESCRIPTION: The Army has a need for quiet tactical operation, reduced logistics burden, and greater fuel efficiency in portable power generation applications. Fuel cell technology has good potential for addressing many of these military needs. The primary barrier to the use of fuel cells on the battle field is the inability to operate on existing military logistics fuels; diesel and JP-8 (military users of power systems are mandated by DoD Directive 4140.25 to use only logistics fuels). Military logistics fuels contain high levels of organic sulfur compounds (up to 3000 ppm, weight basis), high concentration of polyaromatic hydrocarbons and the composition of logistics fuels can vary greatly. Sulfur in fuels can poison many commonly used reforming catalysts and electocatalysts. Polyaromatic hydrocarbons are difficult to reform, typically have long residence times and are associated with carbon formation in fuel processing systems. Large variability in fuel composition dictates that a robust fuel reforming approach be used.

A means for removing sulfur in the fuel processing system which is compact, efficient, regenerable under operation, and operates at low pressures is needed. Additionally, the regenerable sulfur scrubber must be compatible with the selected fuel reforming system as well as the target fuel cell stack technology. Of significant concern in fuel processing is the sulfur-tolerance and coke-resistance of the catalyst used in the fuel reformer. Other desirable characteristics of the sulfur removal/fuel processing system is good thermal cycling capability, high turn-down ratio, rapid start from cold conditions, compact design, and good thermal efficiency.

This effort seeks to identify an integrated regenerable sulfur removal/fuel processing system which can operate across the broad definition of logistics fuels and produce a product stream compatible with fuel cells. Laboratory feasibility investigations conducted in phase I will be applied to the design, development, and construction of a laboratory demonstrator prototype in Phase II. The laboratory demonstrator prototype will be tested and evaluated to discern possible near-term benefits to the U.S. Army.

PHASE I: Demonstrate the feasibility of the regenerable sulfur removal technology via laboratory experimentation. Laboratory experimentation should demonstrate sulfur absorption efficiency, parasitic energy demand, and life of regenerable sulfur removal system. Additionally, a laboratory reforming reactor should be used to substantiate postulated performance, reforming efficiency, sulfur tolerance, carbon formation avoidance, and some indication of life. The results of the laboratory research shall result in the identification of a specific process (unit operations, key operating parameters and operating conditions, and a preliminary system design) to desulfurize and process JP-8 and diesel liquid fuels.

PHASE II: Construct, evaluate, demonstrate, and deliver a laboratory demonstrator prototype system. The prototype must deliver a fuel stream compatible with the identified fuel cell technology when used with JP-8 and diesel fuels. The prototype must be able to deliver this reformate within 30 minutes of being activated from a cold start and have an operational life of at least 1000 hours.

PHASE IIII/DUAL USE APPLICATIONS: Developments in fuel processing and sulfur removal from logistics fuels for use with fuel cells will have immediate impact on a wide range of military applications as well as commercial power sources such as auxiliary power units for the automotive, trucking, and recreational vehicle industries.

REFERENCES:
1) X.Qi and M. Flytzani-Stephanopoulos, "Activity and stability of Cu-CeO2 catalysts in high-temperature water-gas shift for fuel cell applications ", invited paper, Ind. & Eng. Chem. Res., 43, 3055-3062 (2004).
2) Chunshan Song, “New Approaches for Deep Desulfurization for Ultra-Clean Gasoline and Diesel Fuels: An Overview”; Fuel Chemistry Division Reprints, 2002, 47(2), 438.
3) Ma, X.; Velu, S.; Sun, L; Song, C.; Mehdi, N.; Siva, S. “Adsorptive desulfurization of JP-8 jet fuel and its light fraction over nickel-based adsorbents for fuel cell applications “, Am. Chem Soc Div Fuel Chem Prepr. 2003, 48, 526.
4) Kopasz, J; Applegate, D.; Miller, L.; Liao, S.; Ahmed, S.; “Unraveling the maze: Understanding of diesel reforming through the use of simplified fuel blends”, International Journal of Hydrogen Energy, 30 (2005) 1243-1250.

KEYWORDS: fuel processing, regenerable sulfur removal, logistics fuels, fuel cell, auxiliary power unit (APU)

A06-097 TITLE: Micro-Power Generation Suite For Future Combat Systems (FCS) and Global War on Terror (GWOT): Watts To Kilowatts

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM Mobile Electric Power

OBJECTIVE: To develop an alternative suite of electric power generating building blocks that can be configured into highly power dense, hybrid, load following power systems in the 2 to 15 kW range. A suite of next generation, dual use power systems is sought that will:

- optimize the operational effectiveness of Future Forces Future Combat Syttems (FCS) tactical C4ISR applications.
- maintain command and control functions for Commercial ‘new economy’ components (Internet, communications, banking, etc) which enable information connectivity critical to national safety during Global War On Terror (GWOT) and disaster relief activities.

DESCRIPTION: Whether they are to be used in support of a joint, interdependent, full spectrum, mission-tailored force on a tactical battlefield or in areas under collapse conditions, the emerging suite of tactical power systems of the 21st century must be adaptable / flexible / reliable to support the power needs of a digital age in various areas and under varying environmental conditions.

Both Army platforms and the communication components of the ‘new’ economy are dependent on continuous computer control and information flow and in turn on computers and electronics which control everything digitally. Thus the linchpin to successful operation of both Military C4ISR and commercial C2 is versatile, hybrid, distributed power systems.

The solution sought is highly power dense, hybrid, load following power systems based on alternative power technologies in the 2 to 15 kW range. (Note: the goal is not necessarily to provide a single system that will address the entire 2-15 kW range, but to address a power level or range within this range.) The resulting power suite must enhance strategic responsiveness and core war fighting capabilities of various Future Combat System (FCS) platforms and must address the power needs of ‘new’ economy applications used to enable the rebuilding of nations and maintain critical information connectivity. Such a solution has potential to afford soldiers the capability of “plugging in’ to a variety of common power systems.

PHASE I: Identify/specify emerging power conversion and generation technologies and energy storage technologies that will yield advanced power generating building blocks for integration into a highly power dense, load following power system in the 2 - 15 kW (nominal) range. Power technologies of interest include advanced/alternative atomization/vaporization techniques and performance enhancing materials; JP-8 fuel burning engines (Stirling, Microturbine, etc) Power Electronics Controls and Conditioning, Advanced Energy Storage, renewable (Photovoltaics, Thermophotovoltaics, Thermoelectrics) energy technologies, advanced batteries, and system integration and control technologies which promote a fully sustainable energy system on a world-wide basis that are environmentally friendly. Selected components/subsystems shall be electrically compatible with tactical applications. Technology drivers shall be size, weight, and cost.

Components and subsystems selected shall enable the following basic design requirements for the desired power source operating at full rated load:

- Fuel: JP-8 fuel burning
- Output: 2 - 15 kW of continuous power output from sea level up to 4000 feet, 95oF (1219 m, 35 oC) with no degradation.
- Environment: operating at sea level with no degradation of power output within a temperature range from - 25F(-2C) to + 140F(+60C) at any possible relative humidity within this range.
- Fuel Consumption: reduce fuel consumption from a battlefield “system” standpoint
- Power Quality: per MIL-STD-1332B
- Weight: reduce by 50 % defined 2 – 15 kW TQG weights

Develop conceptual power component and subsystem designs per the above. The designs should include the following elements:

a. Narrative and graphical depiction of the design
b. Projected physical attributes (size, weight…)
c. Projected performance metrics (fuel consumption, power output, etc.)

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.

Using a decision model, or another suitable approach, the contractor shall propose an optimal combination of critical power components for development in Phase II and integration into an operational hybrid, load following power mule capable of providing continuous output power and operating on JP-8 fuel. Component/Subsystem designs shall consider integration issues.

PHASE II: Component Fabrication / Integration of Mule / Testing: The component and subsystem designs from Phase 1 will be fabricated, 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 load following power system demonstrator. Develop a business case analysis showing how the electric power generating building blocks would benefit the Army / DoD. Develop a marketing strategy for launching the building blocks into a commercial market segment.

PHASE III: The results from the Phase II effort will afford the contractor the capability to provide industry an advanced state-of-the-art load following power source with increased power density and increased fuel efficiency that can support a wider range of loads. Potential commercial applications for a mobile higher power density system that consumes liquid fuel and that can effectively provide continuous power output, follow load and efficiently convert JP-8 fuel to electricity for either primary or backup power for emergency mobile hospitals, temporary field police stations and developing nations. All Solutions will directly impact/support commercial proposals provided in response to upcoming DoD procurements through PM-MEP for power sources in the 2 - 15 kW range that support the Small Tactical Electric Power Program.

It is imperative that both DoD and Commercial sectors focus on advancing/broadening the design approaches of the next generation power families so that they can address not only the tactical electric power needs of the battlefield but also the power needs of ‘new’ economy components that aide GWOT applications, and disaster relief activities. The results of this development effort will help to advance and broaden the design approaches of the next generation power families developed in support of GWOT applications, of rebuilding nations, supporting disaster relief activities and back up power systems for homes and hotels in times of weather-related electric outages. The decision model approach used in phase I should be applied to commercial applications.

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http://www.arcic.army.mil/Key%20Documents/p525-66.pdf

KEYWORDS: alternative suite of electric power generating building blocks; optimized combat effectiveness, enhanced strategic responsiveness; highly power dense, hybrid, load following power systems

A06-098 TITLE: Innovative Integration Layer for Signal Analysis Support

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop an innovative architectural layer for information integration to support ground analysis of communications signals and patterns to enhance capabilities of Army signals intelligence & electronic warfare (SIGINT & EW) systems such as Prophet and the Enhanced Trackwolf direction finding and intercept system.

DESCRIPTION: Ground based analysis of signal intelligence is a labor intensive and difficult process where important information can be lost due to poor communications quality or high operator workload. New architectures for Army systems of the future are currently in development [Reference 6, 7]. These architectures will offer new capabilities for interoperability of structured and semi-structured information. Longer term, the goal is to also include support for unstructured data, however a significant technology gap exists.

To address this gap, an innovative architecture for unstructured data management, correlation and knowledge discovery is needed to assist the analyst by capturing data and metadata for rapid and intelligent retrieval of critical information. The layer’s basic architecture must support both a taxonomic and graphical set of relationships between data elements.

It is envisioned that as signal data is captured it will be processed into the integration layer along two parallel paths. Using voice intercept processing and analysis consider the following example: Along one path the signal data will be captured and tagged with metadata including temporal, geospatial and electromagnetic characteristics. The second path will apply voice recognition and speech pattern analysis. The results of this analysis will be captured in its transcribed form. Speech to text transcription should be obtained from a voice recognition front end which may be a standard Government voice processing tool or a commercial tool using an open standard such as VoiceXML.

The desired areas of innovation are in unstructured data discovery, integration and understanding (by the user). An important capability of the information layer is that it must support ad hoc queries that consider not just data but also relationships between types of data. This will result in shorter retrieval lists of highly relevant information. In order to be successful this information management layer must result in an improvement to the analyst’s productivity without a significant increase in workload. The overall objective will be to make the analyst more effective. Innovative approaches to the integration layer architecture are needed to meet these requirements.

The focus of this SBIR is on innovation in the area of integration and accessibility of unstructured data to support more insightful analysis. For the purpose of this SBIR the use of voice data will provide an acceptable demonstration; however the basic architecture must not preclude the integration layer from managing other types of signal analysis data and tools.

PHASE I: Using the reference architectures [References 6, 7] as a baseline, produce a set of requirements in use case form to capture the core needs of the information integration layer. Develop a prototype of this integration architecture using a simulated signal input to demonstrate the ability to store and retrieve information.

PHASE II: Develop an operational prototype and conduct a demonstration of the prototype. This prototype will be assessed as to its real-time performance, ability to provide relevant ad hoc queries and provide useful assistance to the analyst. Findings will be documented in a final report.

PHASE III DUAL USE APPLICATIONS: Dual use would be applicable wherever there is a need to perform signal analysis and recognition as well as retention for further analysis. Army applications would support the Warfighter through productivity boost for analysts charged with processing large volumes of signal traffic for critical information. Systems such as Prophet and the Enhanced Trackwolf would benefit from these new capabilities. Within the commercial sector, the capability to leverage unstructured information sources (such as voice) would enable highly efficient call centers and expand current voice interaction efforts.

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2) Enhanced Trackwolf Overview: http://www.globalsecurity.org/intell/systems/trackwolf.htm (non-Government site)
3) Prophet Overview: http://www.globalsecurity.org/intell/systems/prophet.htm (non-Government site)
4) VoiceXML Standards Development: http://www.voicexml.org
5) Proceedings from the 13th IEEE International Workshops on Enabling Technologies: Infrastructures for Collaborative Enterprises (WETICE-2004): http://csdl2.computer.org/comp/proceedings/wetice/2004/2183/00/21830065.pdf
6) Distributed Common Ground System Integration Backbone Technical Requirements Document: http://peoiewswebinfo.monmouth.army.mil/portal_sites/IEWS_Public/workspace/AF%20DCGS/Atch%204%20DIB%20TRD%2019%20Sep%2003.doc
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KEYWORDS: signals intelligence; electronic warfare; integration; unstructured data

A06-099 TITLE: Low Jitter Clock Source for Radio Frequency Data Converters

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To develop 40-100 GHz (gigahertz) oscillators with extremely low cycle-to-cycle jitter for integration with ultrafast digital and mixed signal circuits.

DESCRIPTION: The goal of a true software radio is direct digitization of received radio frequency (RF) signals followed by all-digital signal processing that is software controlled and reconfigurable. Towards that goal, high performance analog-to-digital and digital-to-analog converters are being developed. High quality clock sources and clock distribution schemes are essential for continued enhancement of these RF data converters. Precise 20-100 GHz on-chip oscillators with very low-jitter (10-100 fs (femtosecond)) are required for replacement of expensive, external clock sources with higher jitter. Also required are clocking and clock distribution schemes that can exploit the superior short-term phase stability of these oscillators. Approaches that include a phase locking scheme to an external lower frequency reference to ensure good long-term stability are preferred.

PHASE I: Develop a clock technology for on-chip integration with data converters featuring direct digitization at RF. Design and if possible demonstrate an on-chip clock source with desired short- and long-term phase stability.

PHASE II: Develop and demonstrate a digital-RF receiver front-end incorporating an on-chip clock source. The system to be delivered will be an integrated circuit chip having a receiver with an on-chip clock source.

PHASE III: Military Application: Primary applications are digital-RF transceivers for the next generation terrestrial and satellite communication systems (e.g., JTRS (Joint Tactical Radio System), MILSATCOM (Military Satellite Communications)). Other applications for the improved clock technology include digital true-time delay for phased-array RADAR and broadband spectrum monitoring systems for SIGINT (Signal Intelligence) and EW (Electronic Warfare) applications.

Commercial Application: In addition to transceivers for commercial wireless and satellite communications, faster digital and mixed signal electronics, enabled by superior on-chip lock sources, will find applications in the high-end instrumentation market. The clock source may also be developed into a stand-alone product for various digital and mixed-signal applications.

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KEYWORDS: clock jitter, femtosecond, on-chip oscillator

A06-100 TITLE: Reactive, Multi-Layer Simulation Technologies

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate an approach to modeling and simulation of the operation and performance of distributed applications across multiple levels of the communications protocol stack.

DESCRIPTION: Accurate analytical and simulation-based performance and interoperation assessments of Advanced Network Centric Warfare (NCW) systems are critical to the successful implementation of the Army’s Future Force. While a multitude of modeling and simulation tools are available to address network analysis at various levels of the communications stack, these tools remain deficient in that they do not provide cross-layer interactions in a reactive manner, nor have the tools been successfully combined into a single and accurate tool set. For example, many electro-magnetic (EM) tools are capable of analyzing antennas and propagation; network simulators are well suited to analyzing media access, routing and transport protocols; and various software tools and techniques apply to software simulation. However, combining these diverse modeling and simulation approaches into a self-consistent tool set remains elusive.

NCW tactical systems, as currently envisioned, include a multitude of fixed and mobile entities interacting via multiple applications, including collaborative tools, media streaming, Voice-over-IP, semi-autonomous robotic entity control, etc. These networked applications are typically composed of middleware, mobile agents, and other advanced software. They are often developed by organizations other than those developing the network and its associated flow control, routing algorithms, and hardware. Of course such software reacts to network conditions and the physical environment; yet a systematic means to collectively and simultaneously assess and optimize the many factors at various communications stack levels is largely unavailable. Obviously, distributed application software can be optimized if knowledge of the network and its dynamics are known in advance or discovered during deployment (e.g. see [7]). Critical factors influencing cross-level stack effects include, but are not limited to, timer and protocol settings, routing algorithm selection, and antenna design/control.

Nevertheless, there is a distinct lack of targeted effort towards the development of a simulation/emulation capability that provides an accurate means for assessing and developing distributed applications in complex and unreliable network environments. See [5-6] as general references on network simulation and emulation. Much of the existing research in cross-layer design and optimization tends to focus on specialized formulations or specific areas (e.g. see [13-14] rather than provision of general-purpose assessment able to span many levels of the protocol stack.

Moreover, this area is generally focused on transport and below layers and does not include the application layer which is a focus of this effort. Computer-aided application software development is often times carried out using UML. While the recent focus on 'executable' UML [11-12] aids in the development of class structure and interaction, it does not typically extend to detailed quantitative assessment, correctness testing and optimization in various non-ideal networked environments. And it also does not provide a capability for treating software that was not initially developed using a UML approach.

The use of abstraction at communications stack layers above and below the level of interest is suggested in [4] to enable very large scale simulations, and a similar simplification for the network layer is suggested in [8]. Unfortunately, detailed and potentially critical interaction effects and artifacts can be missed in such approaches. Furthermore it is unclear how abstract executable models of lower and upper layers would be constructed such that they were known to be correct and exhibit the full range of possible behaviors truly present. There has been some recent work aimed at cross layer simulation that includes the application level in [9-10]. These have various limitations in that only a particular source language can be used, only makes use of overly simplified models at various protocol levels, or lacks the ability to leverage existing models specialized in certain areas.

The tool set to be developed must therefore enable the quantitative performance assessment of complex distributed systems, where the analysis accounts for influence by the layers of the communication regime. Particular focus will be on applications and networks deployed in ad hoc wireless environments. In addition to performance analysis, the tool set design should also support system optimization, ranging from parameter adjustment to selection of system components. For example, simulations might address determining the benefit of an improved antenna or data coding scheme, determining the best ad hoc routing method, investigating impacts of various situational-awareness update strategies, human factors, and many other multi-layer network factors.

The goal of this topic therefore is to explore new techniques for merging analytical tools and/or simulation methods that capture at least two levels in the communication stack, which could encompass physical, data link, network, transport, middleware, and application layers (or alternative layers in other stack representations). New tools that operate primarily within a single level, or that include only minimal cross-layer aspects, are not to be addressed in this work. Likewise, methods that do not provide reactive and self consistent assessments across layers, such as using simplified data extractions from one layer to another, are not to be addressed, unless the approach provides some means for proper inclusion of reactive actions between layers. Approaches that allow incorporation of human or hardware in the loop (HITL) within a modeled simulation environment, again assuming that the simulation spans multiple levels, are encouraged. The use of commercial and military standards, such as UML and HLA, is useful but not required; the focus of this work should be directed towards new research on cross-layer simulation of complex C4ISR systems where the analysis accounts for lower layer effects in an accurate and cross-layer reactive way.

PHASE I: Develop new cross-layer simulation concepts and quantitative assessment techniques that span multiple layers of the protocol stack. Identify output metrics that the cross-layer analysis methodology should provide, as well as the inputs required for the analysis. Highlight the advantages of the new approach against existing tools and methods. Account for practical problems such as the influence of lower communications stack timing delays on higher level application performance, as well as methods to integrate real application software and systems into the simulation environment. Emphasize innovative approaches that enhance simulation speed, ease, user interaction, and accuracy such as the use of COTS multi-core processors, inter-process memory sharing/communications, leveraging of GRID computing methods, and model re-use. Present applicability of approach to service-oriented network architectures.

PHASE II: Develop new tools and techniques based on Phase I efforts, implementing novel simulation concepts. Demonstrate and assess the prototype tool in terms of meeting performance goals and capabilities established during Phase I. Also develop appropriate benchmarks to exercise the cross-layer modeling and simulation concepts and confirm their validity.

PHASE III: Utilizing the concepts and prototypes developed during Phase I and II, develop a working set of commercially-deployable modeling and simulation tools for use by DoD and commercial customers. Transfer results into commercially viable simulation products.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This technology has applicability to any organization deploying distributed software systems in various network environments. These organizations include public operators of mobile broadband (including 3G) networks, telco and cable operators (especially in large scale IP-based services), emergency responder radio networks, etc.

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KEYWORDS: cross-layer simulation, distributed systems, networks, middleware, physical layer

A06-101 TITLE: Image and Character Restoration Module for Arabic Text Documents

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Develop automated preprocessing techniques to restore degraded documents with Arabic text, leading to higher Optical Character Recognition (OCR) rates.

DESCRIPTION: One of the continuing challenges facing U.S. warfighters is the ability to translate foreign text contained in documents, such as photo images of signs, fax copies or machine printed Arabic text documents. There are several commercially available multi-lingual OCR engines designed to process machine produced Arabic script. However, the performance of these OCR engines is significantly reduced when the original document contains even marginal level of noise or defects. Examples of document degradation include smudge marks, discoloration due to aging, stains, handwritten notations, tears, hole-punches, crumpling, or simply documents generated from a low – end printer/copier. Documents also contain artifacts such as lines, watermarks, logos and stamps that interfere with OCR algorithms by cutting across the main text and obscuring the characters. Current known commercial image enhancement and restoration products/techniques only partially satisfy the stringent military requirements to restore documents for successful Arabic OCR readability. Existing image enhancement products handle generic noise such as speckle, skew and edge noise, but do not adequately perform image enhancements and restoration of Arabic characters. It is anticipated that artifact removal and character repair will require the use of specific graphical features of Arabic script.

Under this solicitation, we are looking for an Arabic-specific preprocessor to perform image enhancement and text repair on machine-produced (not handwritten) Arabic text documents. The preprocessor needs to connect as seamlessly as possible with commercial Arabic OCR programs and will need to demonstrate performance enhancement without any manual intervention. Desired functionality includes: (a) removal of lines, watermarks, logos, stains and stamps that cut across text in hardcopy pages, (b) restoration of broken or incomplete Arabic script characters, (c) Arabic-specific noise removal, (d) standard non-language-specific image enhancement techniques, (d) compatibility with a variety of image types (i.e. bitonal, grayscale, color), file formats (i.e. jpg, tif, png, etc), and resolutions (100, 200, 300 dpi, etc), (e) fast processing (<15% of the time required for OCR), (f) small foot print, (g) ability for the user to control all cited functionalities through an application programming interface (API).

PHASE I: Phase I- Compile a set of algorithms suitable for cleaning machine-produced Arabic text documents. Perform initial implementation of select algorithms and demonstrate feasibility on sample text. Document the algorithms and analysis and provide a projection of expected performance in the final report.

PHASE II: Phase II- Complete the implementation of the algorithms explored in Phase I and produce a fully functioning prototype system. Demonstrate improved OCR performance on moderately degraded documents of letter size with font sizes ranging from 1.5 mm to 6.0 mm, 200 Arabic words per page, and a minimum of 10 lines of text requiring artifact removal. Deliverables will be the preprocessing software and a final report documenting all activities in the project, including a user's manual for the software.

PHASE III: Apart from the obvious commercial applications in Arabic document processing, a fully automated Image and Character Restoration Module has application in categories such as medicine, forensics, astronomy, and satellite imagery. Military applications include document processing in the intelligence community and will be applicable for documents in other languages based on derivatives of Arabic characters (i.e. Farsi, Urdu and Pashto).

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b- NLP-Enhanced Exploitation of Degraded Arabic Text Michael Shalev, Encyclopedia Britannica.

c- Fast Skew and Slant Correction for Arabic Written word of Line (Essam M Zaki and M El Adawi, SAKHR USA Inc).

d- A Process Flow for Realizing High Accuracy for OCR Text (Kazem Taghza, Julie Borsack and Tom Nartker, University of Nevada, Las Vegas.

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7- Work Shop announcement- Computational Approaches to Semitic Languages. http://www.cs.um.edu.mt/~mros/WSL/.

8- Predicting Intelligibility from Fidelity in MT Evaluation by: John White Litton PRC, 1500 PRC Drive, McLean VA 22102 white_john@prc.com.

9- In One Hundred Words or Less by: Florence Reeder MITRE Corporation- 7515 Colshire Drive, McLean, VA, 22102 USA freeder@mitre.org.

10- OCR Scanning Services for Accurate and Affordable Automated Data Capture http://www.compupacific.com/services/ocr.shtml

KEYWORDS: Image accuracy and image enhancement techniques, Image analysis, noisy document, random noise, repair Arabic letters, remove noise form corrupted document, linear filtering techniques, Repair text charcter improve OCR rate, MT, NLP, small fonts, accuracy, fidelity, and intelligibility, and, diversified forms of data/documents

A06-102 TITLE: On-the-Move Geolocation of Very Weak RF Signals in Urban Environments

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop a very sensitive, low profile, vehicle mounted, Three Dimensional (3D) geolocation system capable of detecting and geolocating very low power, non-cooperative Radio Frequency (RF) signals within several hundred meters of the vehicle across a wide range of frequencies in urban environments. Provide 360 degree coverage and geolocation capability around the vehicle with a Spherical Error Probable (SEP) of less than 10m. Provide algorithms that support graceful degradation in performance with increasing range, decreasing target signal strength, and decreasing time on target.

DESCRIPTION: The Army requires a low profile, low cost, mobile 3D geolocation system capable of accurately geolocating low power signals. Some of these signals will be on continuously while others will be transient in nature. Systems exist that are able to detect and locate low power communications devices using a variety of cooperative and non-cooperative techniques. A variety of military systems exist for geolocating High Frequency (HF), Very High Frequency (VHF), and Ultra High Frequency (UHF) using angle of arrival and time difference of arrival techniques. Finally, amateur radio and law enforcement direction finding (DF) products that offer the user on the move capability are readily available. However, none of these products meet all of the requirements for geolocating very weak, non-cooperative RF signals in harsh urban environments. Geolocation of very low power signals has proven very difficult for a variety of reasons. Environmental challenges such as multi-path and co-channel interference severely limit the performance of ground-based geolocation systems in urban environments. Receivers that can detect very weak signals across a very large band of frequencies are only now becoming available.

The goal of this program is to develop a very sensitive, low-profile, vehicle mounted, general-purpose RF detection and geolocation system that would map very low power signals in an urban environment using advanced geolocation algorithms combined with a highly sensitive mobile RF receiver and antenna subsystem. The system should detect 90% or more of the weak RF signals present within a 300m or greater radius of the vehicle with the vehicle moving a 60MPH or less. The antennas should be low profile with as small a footprint as possible. Size, weight, and power requirements should be minimized to facilitate mounting the system on a variety of civilian and military vehicles. The system should provide the user with a visual display that maps detected signals surrounding the vehicle.

PHASE I: Feasibility study for a low profile, general-purpose RF sensor with the capability of detecting and geolocating very low power signals in an urban environment. Develop specifications for the receiver and antenna subsystems including required antenna gains, receiver sensitivity, and scan rates. Conduct trade-off analysis on receiver and antenna performance versus detection and 3D geolocation performance.

PHASE II: Design, build and demonstrate a general-purpose RF sensor prototype including the advanced geolocation algorithms. The prototype should be designed to mount on a HMMWV and powered by vehicle power only. Demonstrate the capability against a predefined set of emitters provided by the government in a realistic urban environment. Provide design documentation, a test plan and documented test results.

PHASE III: The completion of this phase would result in a mature technology, that could be successfully applied to both military and commercial applications such as law enforcement and homeland defense. The technology developed as part of this effort should provide the warfighter with enhanced situational awareness and force protection. The technology is also directly applicable to homeland defense and could be used by law enforcement to detect RF devices.

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KEYWORDS: geolocation, urban environment, military operations in an urban environment (MOUT)

A06-103 TITLE: Advanced Fast Tuning Low Phase Noise, Low Power Consumption, Wideband Tuner for Electronics Warfare (EW) Applications

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Design a wideband tuner that is, fast tuning and low phase noise.The tuner must have sufficient Intermediate Frequency (IF) filtering to output spectrum to modern digitizers in order to avoid aliasing.It should be capable of receiving signals from 20-X MHz, extendable to Y GHz.

DESCRIPTION: Modern EW applications & systems require front end tuners that are faster, wider bandwidth, more power efficient, and smaller than are presently available in the industry today. The development of such a sophisticated tuner technology will greatly advance the EW industry. Having an advanced fast tuning, digital gain control, low power consumption, wideband tuner is essential to creating EW systems that can address those threats.

Typically in wideband tuner design, fast tuning and phase noise have to be traded off; this advanced design will demand that both parameters are optimized at the same time. The tuner must have sufficient IF filtering to output the spectrum to modern digitizers in order to avoid aliasing. The new tuner module should be capable of receiving signals from 20-X MHz, extendable to Y GHz. The device should be packaged in a chassis of no larger than 50 cubic inches. The DC power consumption must be no greater than 10W with a tuning time between any two frequencies of less than 50 microseconds. The IF output bandwidth must be equal to or greater than 40 MHz. Command and control must be through a high speed interface and the tuner must have a Built-In-Test capability.

PHASE I: Provide a feasibility study for a low cost widebdband tuner. Develop a Theoretical Model, and a preliminary Technical Specification for tuner.

PHASE II: Design, build and demonstrate a prototype wideband tuner including the mechanical enclosures. Wideband Tuner tests should be conducted in an environment emulating the intended applications of the tuner. Generate a report showing the result and comparisons to the theoretical model and any deviations from expectations.

PHASE III: The completion of this phase would result in a mature technology, which could be successfully applied to both military and commercial applications such as law enforcement and homeland defense.

REFERENCES:
1) Digital Techniques for Wideband Receiver, James Tsui
2) Electronic Packing for High Speed Circuitry, Stephen G. Knosowski and Arden R. Helland.
3) Software Defined Radio, Enabling Technology, Walter Tyttlebee.

KEYWORDS: Electronic Warfare (EW), Jammers, Direct Digital Synthesizers, Compact Packaging, Fast Tuning, Programmable, Improvised Explosive Devices (IED), Wireless, FCS, WarLock, Wideband

A06-104 TITLE: Portable Terahertz Imaging System

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop a portable, cost-effective, high-power, Terahertz Radio Frequency (RF) system (transmitter/receiver circuit) for use in current and future military applications, specifically handheld/portable imaging systems.

DESCRIPTION: The Terahertz frequency band, from roughly 300 GHz through 10 THz, is thought to be the most under-explored region of the electromagnetic spectrum. A major problem that prevents the full exploitation of the THz band is the lack of affordable, compact, high-power THz sources and receivers. Previous research has shown that semiconductor technology can be utilized to create THz transmit and receive modules which are fairly compact; however, their efficiency is poor, they are low power, costly and their frequency agility is lacking. Many of the current cutting-edge systems have been limited to laboratory workbenches. Moreover, the current commercial technology is macro in scale and relatively low power, with only Optically Pumped Terahertz Laser sources approaching single Watt output power (and this is only for certain frequencies within the THz band).

Current THz technology has allowed for the demonstration of high resolution three dimensional (3D) imaging through a variety of common mediums (such as clothes, leather, wood, ceramics, semiconductor materials, human epidermis, etc.). High resolution imaging capabilities are desired for a number of military and commercial applications including medical diagnosis, security screening of people and cargo, sense through wall applications, and biochemical agent analysis. A major limitation of current THz imaging modalities is the required collection time of the image. Most high resolution systems require many minutes to hours in order to collect a single image. This is often due to a lack of cost effective sources/detectors leading many systems to implement only one source which means that the source must be mechanically scanned across the sample to create the image. Leveraging current technology and fabrication techniques in order to develop a more cost effective and efficient source and detector would help to alleviate the collection time problem by allowing for more sources/detectors per system. Designing new algorithms and software as well as optimizing current algorithms/software for the collection and processing of 2D and 3D images would also help to alleviate the collection time problem.

Moreover, in the realm of medical imaging THz is currently only able to be used for diagnosis of dermal anomalies such as distinguishing between healthy and cancerous skin in collected samples. It has also been shown to have promise in diagnosing other skin level ailments such as burns and fractures in phalanges (where there is little muscle tissue around the bones). Due to the low-power capabilities of current systems and the inherent absorption of THz RF by polar molecules (such as water), achieving high levels of penetration into human tissue has not been very successful. The signal to noise ratios required to detect reflections/transmissions of the current systems are rather high due to the low power of transmission. Leveraging current technologies to develop a more efficient high power emitter would help to alleviate this boundary in medical imaging applications.

With the increasing need for technologies that could utilize a complete THz system, it is vital that an affordable THz RF system be developed. Not only can such a system be incorporated into many portable applications in the medical imaging, security and defense fields, but it will also make the study of THz technology more approachable for an lightly funded laboratory. Thus, even more expansion in THz research could be realized. The THz band also lends itself to a high degree miniaturization (of antennas, etc.) making highly portable (i.e., handheld) devices a practical vision for the future.

The goal of this program is to develop a cost effective, portable, high-power Terahertz RF system that can be used to explore the battlefield viability of THz technology and aid current Advanced Technology Objectives (ATOs) in their completion. Due to the portability requirement, a guideline for the design of the system is a gross weight of 15 lbs. The cost, degree of miniaturization, and peak power of the system proposed will be left for the phase I feasibility study.

PHASE I: Feasibility study for the terahertz system to include degree of miniaturization, degree of improvement to cost (through novel fabrication techniques for example), and degree of improvement to power output possible by leveraging current technologies (i.e., Optically pumped lasers, Time Domain Spectroscopy Systems, Backward Wave Oscillators, Direct Multiplied Sources, etc.) and investigation into innovative conceptual designs for miniaturized (i.e., handheld), cost effective, high power THz transmitters and receivers. As well as a study of possible algorithms/software to increase the effectiveness and timeliness of 2D and 3D image collection.

PHASE II: Design, build and demonstrate prototype THz RF transceiver circuit/system. Design and document software/algorithms for efficient, high-speed 2D and 3D image collection.

PHASE III: The completion of this phase would result in a mature technology/system which would undergo an appropriate operational demonstration, such as imaging military cargo, medical diagnostics of battlefield wounds and personnel security scanning. The system would then be applied to the commercial medical imaging community as well as commercial security applications in law enforcement, homeland defense, etc.

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Sudworth, C. D., et. al. Optical Properties of human tissue at terahertz frequencies. Progress in Biomedical Optics and Imaging, 24 June 2003, SPIE.
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KEYWORDS: Terahertz, transmitter, receiver, medical imaging, bone fracture, handheld, portable, Imaging System, health monitoring, manufacturing cost, manufacturing efficiency, fabrication, solid state, optoelectronics

A06-105 TITLE: Propagation Modeling of Near Ground Radio Signals

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The objective of the Topic is to develop an accurate model of near ground progation in the 30MHz to 3GHz frequency range. The model will be useful to characterize the performance of Signals Intelligence (SIGINT) ground systems and other ground sensors against all signal types and in all environments. This model would have wide application not only to SIGINT systems but also in commercial industry. Tri-Service utilization would also be expected. This also has applicability to PM CREW interests.

DESCRIPTION: The Army requires many systems to operate at or near ground level, both static and on-the-move. Areas such as, but not limited to, robotic based sensors, SIGINT ground collection systems, and other classified systems critical to the Army's ability to fight and survive on the modern battlefield. Such proposals shall be largely based on mathematical theory, easily modeled on computers, and may be supplemented on a limited basis with new empirical data. The frequency range of interest is 20 MHz to 3 GHz. The height of the antennae are within 1 meter of the ground. The propagation model must address various code access schemes and modulation schemes, as well as the effect of the various methods effect on propagation of the radio waves of interest. The frequency range of interest may require different models to accommodate an accurate prediction of the radio phenomenology in this total band. Propagation over grass, sand, gently and rapidly sloping terrain, dense and less dense wooded areas, wet marshes, water, urban, rural and sub-urban areas are also to be included in the model. The diurnal and temperature effects shall be considered in the model. Effect of power levels, transmitter thresholds, processing gain (co-herent), and generic pre-amplifier performance shall all be variables considered in the model as they relate to radio wave propagation.

PHASE I: Phase I will provide a feasibility study and outline of the modeling approach to be used to predict radio wave behavior, near ground, in the 20MHz to 3GHz region.

PHASE II: Phase II will result in the delivery of a prototype software based model. The model will accurately predict the propagation of radio waves at near ground level. During Phase II the model will be tested against real field data from SIGINT systems and matured based on comparison results of the predicted versus actual data.

PHASE III: The Prediction Model has many military and commercial applications. In the military it will predict ground SIGINT and sensor systems performance accross the TRI-Services to allow PM's to wisely invest funding in technology enhancements for optimum field performance. In commercial industry, it will allow cell phone manufacturers to more accurately place cell towers, predict level of service coverage, and optimize frequency reuse for their corporations products. This model will result in recovering the technology investment required to produce it by lowering overall technology insertion costs and correction of problems earlier in the design efforts where changes are cheaper than later afterward in production or the field where shortfalls and their associated fixes become cost prohibitive.

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2)"A Report on Technology Independent Methodology for the Modeling, Simulation and Empirical Verification of Wireless Communications System Performance in Noise and Interference Limited Systems Operating on Frequencies between 30 and 1500MHz", TIA TR8 Working Group, IEEE Vehicular Technology Society Propagation Committee, May 1997.

KEYWORDS: Radio Wave, Propagation, Modeling, 20 MHz to 3GHz, Near Ground, SIGINT (Signals Intelligence), Sensors, Theory

A06-106 TITLE: <u>Advanced People and Wildlife Discrimination Algorithms for Radar</u>

TECHNOLOGY AREAS: Electronics, 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: Develop advanced algorithms for discriminating between walking people and wildlife based on radar returns.

DESCRIPTION: Ground Moving Target Indicator (GMTI) radar provides an all-weather day-night capability to detect moving targets and provide robust persistent day-night surveillance of regions of interest. In principle such systems, possibly in conjunction with other sensors, could provide semi-autonomous surveillance of large regions, and provide cues/locations to the operator when hostile or unexpected human activity is detected. A variety of airborne and ground based radars and radar networks are being developed for perimeter surveillance, force-protection and so forth. With improvements in radar detection performance, there's a new challenge to sort out returns from vehicles, moving people, and various forms of wildlife and domestic animals. This topic will explore and develop novel concepts for exploiting radar returns to discriminate between vehicles, moving people, and wildlife and other animals. The concepts developed will provide models that can be used with current and future radar projects to help reduce the false alarms caused by wildlife. Provisions need to be made for "training on the fly" modes to tailor the algorithms to the particular motion patterns of that location and season. There currently is no data to support the proposed effort, as the radar technology is currently evolving. This SBIR topic is crucial to improve the effectiveness and utility of these emerging radar systems. Users have indicated concerns with false alarms based on wildlife returns, causing wasted time and resources (human and weaponry). Model based techniques (which do not exist) will minimize the necessity of massive and extremely expensive wildlife data collections.

PHASE I: Identify potential applications and develop and define model based algorithms for discriminating between moving people and moving wildlife.

PHASE II: Using contractor provided resources, model applicable signature data sufficient to refine and test algorithm performance. Algorithms must be refined in order to discriminate moving humans from moving wildlife with a high degree of confidence. The algorithm should be developed using a technical computing and Model-Based Design software. Develop a trade study defining algorithm performance versus radar parameters (i.e., range/Doppler resolution, polarization, etc.) in order to discriminate humans vs. wildlife in GMTI. Identify radar performance and computational processing requirements in order to run algorithms in an operational environment with the desired level of confidence (in near real time). The final report shall contain the results of the trade study, performance requirements, algorithm definitions and executable models. Applicable bands are UHF to Ka.

PHASE III: The technology developed under this SBIR minimizes false alarms in emerging DOD and DHS semi-autonomous radar or radar-networks used for reconnaissance and perimeter surveillance. Other applications might include cued perimeter surveillance around large facilities (e.g., airports, homeland defense, etc.) or wild management applications where radar is used.

REFERENCES:
1) A neural network approach to Doppler-based target classification Martinez Madrid, J. J.; Casar Corredera, J. R.; de Miguel Vela, G.; Radar 92. International Conference 12-13 Oct 1992 Page(s):450 - 453.
2) Wide-band polarimetry and complex radar cross section signatures Riegger, S.; Wiesbeck, W.; Proceedings of the IEEE Volume 77, Issue 5, May 1989 Page(s):649 - 658 Digital Object Identifier 10.1109/5.32055.
3) Neural network adaptive wavelet classification of radar targets Jouny, I.; Kanapathipillai, M.; Geoscience and Remote Sensing Symposium, 1994. IGARSS '94. 'Surface and Atmospheric Remote Sensing: Technologies, Data Analysis and Interpretation'. International Volume 4, 8-12 Aug. 1994 Page(s):1889 - 1891 vol.4 Digital Object Identifier 10.1109/IGARSS.1994.399603.
4) Target classification by conventional radar Huang Jianjun; Huang Jingxiong; Xie Weixin; Radar, 1996. Proceedings, CIE International Conference of 8-10 Oct. 1996 Page(s):204 - 207 Digital Object Identifier 10.1109/ICR.1996.573807.
5) Radar Handbook, 2nd Edition Merrill Skolnik McGraw Hill, NY 1990 ISBN 0-07-057913-X Radar Cross Section Handbook, Volume 2 George T. Ruck Plenum Press, NY 1970 SBN 306-30343-4.
6) Radar Cross Section "Its Prediction, Measurement and Reduction" Eugene F Knott, John F Shaeffer, Michael T Tuley Artech Itouse, Ma 1985 ISBN 0-89006-174-2.
7) Radar Design Principles "Signal Processing and the Environment", 2nd Edition SciTech Publishing, NJ 1999 ISBN 1-891121-09-X.

KEYWORDS: Manufacturing workforce, assembly, information technology devices, production engineering

A06-107 TITLE: Improved Efficiency of 2.09 Micron Pump Laser

TECHNOLOGY AREAS: Sensors, Electronics

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

OBJECTIVE: Develop a laser source operating at 2.09 microns for use in a next generation distributed aperture Infrared Countermeasure architecture.

DESCRIPTION: The US Army is currently fielding Infrared Countermeasure (IRCM) systems for jamming infrared threats to helicopter platforms. Army IRCM systems use a mid wave infrared laser and a mid wave infrared lamp to defeat threats in different bands of the infrared spectrum. Army IRCM systems use a mechanical gimbal and an articulated arm with mirrors to pass the laser and lamp energy from the source to the exit aperture.

Current Army IRCM systems are capable of countering today’s threats, however, they are expensive systems in terms of production cost and Operation and Maintenance cost. Current systems use 2 sources, a laser and an infrared lamp, to cover the required infrared bands. The mechanical gimbal is an expensive item that will require maintenance to work effectively. The articulated arm has to be precisely aligned in order to pass the infrared energy.

The Army Science and Technology community is currently working on developing the next generation architecture for infrared countermeasures. The major advantages in this new architecture are the elimination of the multiple infrared sources in favor of a single multiband laser; smaller, less complex beam steering devices to replace the gimbal; and Mid-wave Infrared fibers to replace the articulated arm. To achieve the energy in the multiple infrared bands, the multiband laser will make use of optical parametric oscillators, which will output energy at multiple bands given an input pump of 2.09 microns. Lasers at 2.09 microns exist today commercially, however, not at the power and efficiency necessary for implementation on military platforms. Improving the efficiency at the 2.09 microns pump stage will improve the overall throughput of energy on the target and aid in defeating threats.

The goal of this program is to improve the efficiency of a laser that can be packaged for use on a helicopter platform. It should have a wall-plug efficiency of more than 10% at continuous wave operation. The entire pump laser system should be capable of delivering greater than 40W of power at 2.09 microns. Size should be no greater than 18”Wx6”Hx12”D. Weight should be less than 30lbs. The laser must be capable of being packaged for implementation on a helicopter platform.

PHASE I: Feasibility study for improving the efficiency of 2.09 microns laser. Develop a study of the loss mechanisms that hinder efficiency and means to counter them. Perform a study to determine possible architecture changes to allow packaging on a military aircraft environment.

PHASE II: Design and develop a prototype laser with output at 2.09 microns as outlined in the description. Demonstrate laser system power, spectral response and efficiency. Develop and document new packaging design for laser system.
Deliverables will include prototype laser, characterization report, design documents, and any software.

PHASE III: The completion of this phase would result in a mature technology, which could be successfully applied to both military and commercial applications such as medical technology, homeland defense, and aircraft protection.

REFERENCES:
Current work by IPG Photonics (Oxford, MA) and BAE Systems (Nashua, NH) have demonstrated highly efficent 2.09 micron lasers based on thulium fiber laser technology. US Army/US Navy has ongoing work with BAE and IPG under the Distributed Aperture Infrared Countermeasure Program (DAIRCM).

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2) “Intracavity-pumped 2.09-micron Ho:YAG laser”, Stoneman, R., Esterowitz, L., Optics Letters, May 17, 1992, p 736-738

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State of the Art Commercial product
http://www.ipgphotonics.com/html/194_1800-2100nm_range.cfm

KEYWORDS: infared countermeasure, laser, pump laser, laser efficiency

A06-108 TITLE: <u>Prioritization for Improved Effectiveness of Co-Located Wide and Narrow Field-of-View Sensors</u>

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Develop a battlefield object prioritization scheme to maximize the effectiveness of collocated Ground Moving Target Indicator (GMTI) (wide-field-of-view) and Electro Optics/Infrared (EO/IR)(narrow-filed-of-view) sensors. This scheme should impose commander’s Priority Information Requirements (PIRs) on the prioritization logic and should be capable of supporting a range of missions. The prioritization approach should make effective use of domain/environmental knowledge and support enhanced situation understanding.

DESCRIPTION: Future Combat Systems (FCS) is placing considerable emphasis on both extensive, as well as persistent Intelligence Surveillance and Reconnaissance (ISR) coverage. With that emphasis, comes the burden of rapid and accurate analysis of the resulting ISR products. Because additional manpower is not an option, more sophisticated exploitation and fusion algorithms are required to either replace human analysts or, at a minimum, significantly enhance their ability.

GMTI radar systems often cover very large fields of regard, overwhelming analysts with tracks of moving objects. Because tactical GMTI radar systems primarily provide only location, size, and velocity estimates, radar data alone does not support high confidence object classification. EO/IR sensors, on the other hand, provide additional features including shape, color, texture, and thermal characterization of detected objects that significantly increase the potential dimensionality of the decision space.

Of interest is the development of an innovative prioritization scheme to sort object detections in a manner that ensures the most likely targets of interest are prosecuted first, thus ensuring the most effective utilization of both sensor and processing resources. Object prioritization should be based on, but are not limited to, sensor-derived object and track-level features, a priori knowledge, and both dynamic and static battlespace context. The scheme should allow flexible reprogramming to satisfy a variety of mission types as well as support some degree of dynamic adaptation.

PHASE I: Investigate, analyze and document an innovative approach to battlefield object prioritization. Multiple approaches shall be analyzed and documented with the most promising approaches integrated into a real-time algorithm to be developed under Phase II. Modeling and simulation scenarios that will support the proposed scheme during Phase II should be identified.

PHASE II: Develop, code, test, and demonstrate a real-time prioritization scheme, implementing the approach designed during Phase I. The prioritization algorithm shall be developed in an incremental fashion that will permit the Government to provide incremental feedbacks during the development of this code, as well as to allow the algorithm’s contribution to be analyzed at a system level. The baseline effort must be able to support increasingly complex missions and clearly demonstrate how the Commander’s Priority Information Requirements are used to develop tailored and effective mission management.

The majority of the development activity should be geared to a modeling and simulation environment. However, real GMTI radar and EO/IR data will be made available by the Government to support a demonstration phase during the later stages of this effort. A report shall document the final approach, implementation, and results of the overall effort. Deliverables for this phase shall include algorithms and related documentation.

PHASE III: Successful technologies developed under this effort will be transitioned for military application. Many acquisition programs would benefit immediately from this technology including Future Combat Systems (FCS) Unit of Action (UA), Aerial Common Sensor (ACS) and Distributed Common Ground Station - Army (DCGS-A). Potential commercial applications range from security surveillance, to border control by the Coast Guard or INS.

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3) Electronic Warfare for the Digitized Battlefield" by Michael Frater, Michael Ryan - 2001.
4) "Effect of Doppler ambiguities on GMTI tracking" by Koch, W.
FGAN-FKIE, Wachtberg, Germany, RADAR 2002, INSPEC Accession Number:7503907.

KEYWORDS: GMTI, radar, fusion, processing, exploitation, tracking, discrimination, detection, prioritization

A06-109 TITLE: <u>Wideband, Interference Rejecting Antenna Subsystem</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a low cost, low profile, Radio Frequency (RF) Antenna Subsystem that significantly enhances the performance of today’s RF communications and Signals Intelligence (SIGINT) systems by providing a wideband, high gain, dead on the horizon antenna capable of rejecting strong wideband interference sources while providing gain for very weak signals. Demonstrate the system capability through field testing on ground platforms.

DESCRIPTION: The Army requires a low cost/viable capability that facilitates the coexistence of high power broadband transmitters and sensitive receivers on vehicles in close proximity without requiring modifications to the system transmitting or system receiving. It is envisioned that an antenna subsystem replacing the existing receive antenna could null strong, broadband, interference sources and deliver weak RF signals to the receiver. The antenna subsystem should also be capable of receiving over a broad range of frequencies, offering the highest possible gain towards the horizon, and providing high power transmit capability to ensure applicability to both communications systems and SIGINT systems. Today’s military and commercial adaptive array antenna systems are very costly, designed specifically for Global Positioning System (GPS) and therefore not a viable option for the US Army.

A wideband, interference cancellation antenna subsystem needs to have the capability to support today’s modern military communications and SIGINT systems. It should not be assumed that the RF Antenna Subsystem can physically interface to any system other than the one it is supporting and even that interface is limited to RF only. This does not preclude measuring the interference sources at antenna subsystem.

With the increased use of RF systems, need for blue force broadband communications links and proliferation of sensitive SIGINT receivers is vital for the Army to develop a system capable of suppressing broadband interference in close proximity to the receiver. The wideband, interference rejecting antenna subsystem program will enable the Army to carry out multiple missions on the same platform and/or caravan without costly modifications to existing communications and RF systems thus reducing the risk to soldiers.

Interference cancellation techniques have been around for a long-time. Adaptive array antenna technologies on airborne and space-based platforms have taken advantage of beamforming in order to reduce interference. Sophisticated audio headphones sample the surrounding background noise and subtract the noise from the desired audio. Antenna arrays can provide 20 to 30dB of spatial interference rejection. Successive and parallel interference cancellation can provide another 10 to 20dB of rejection. Combination of techniques can achieve even better performance.

The goal of this program is to develop a low cost system that will provide the US Army with the capability to deploy and use a variety of transmitters, communication systems, and SIGINT systems in close proximity to one another without modifying any of the individual systems. In order to do so a Wideband, Interference Rejecting Antenna Subsystem is needed. The total cost of the system shall not exceed $45,000 per unit. The system shall operate over a minimum frequency range of today's existing terrestrial SIGINT and communications systems, provide a maximum gain toward the horizon, be capable of maximum wideband interference cancellation, and provide support for transmission. The weight of each subsystem shall not exceed 50 pounds. The antenna subsystem shall be designed for mounting installation and integration on ground platforms. The system shall be powered by vehicle power only. The antenna profile shall be kept to a minimum.

PHASE I: Feasibility study for a low cost RF antenna subsystem with high gain across a very wide frequency range and the ability to reject one or more very strong wideband interference sources. Develop a cost benefit analysis of gain, wideband interference rejection, instantaneous bandwidth, frequency range, and antenna system size weight and power. Provide a high-level list of the hardware and software necessary to implement the antenna subsystem.

PHASE II: Design, build and demonstrate prototype antenna subsystem for ground-based vehicle mounted applications. Develop and document the antennas, hardware, algorithms, software and test plans required to implement the subsystem. Execute the test plan and determine the performance of the system in terms of gain, frequency range, and interference rejection.

PHASE III: The completion of this phase would result in a mature technology, which could be successfully applied to both military and commercial communications and SIGINT applications. Specifically, the Wideband, Interference Rejecting Antenna Subsystem is directly applicable to the Army's current ground-based and Airborne SIGINT collection and communications platforms. In addition, technology developed as part of this effort can be integrated into the DoD's next generation SIGINT and communications platforms. This technology is also directly applicable to the commercial wireless communications markets.

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http://www.aero.org/publications/crosslink/summer2002/06.htm
2) Lisha Li and Brian D. Jeffs, "ANALYSIS OF ADAPTIVE ARRAY ALGORITHM PERFORMANCE FOR SATELLITE INTERFERENCE CANCELLATION IN RADIO ASTRONOMY",
http://www.ee.byu.edu/rfi/docs/ursi_f_jeffs_2002.pdf

KEYWORDS: Broadband, low-Q antennas, interference cancellation, RF antenna subsystems, adaptive arrays, and antijamming

A06-110 TITLE: Compact, Wideband, Single or Dual Antenna Geolocation

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop and demonstrate techniques to perform geolocation using a compact, wideband, single or dual antenna for applications where array-based Direction Finding (DF) systems are not practical due to size, weight, and cost constraints.

DESCRIPTION: Antenna design is an integral part of the geolocation and DF systems development. Optimum performance requires antenna designs tailored to the operational platform and propagation conditions. When these geolocation and DF systems operate at low frequencies, they often result in increased antenna arrays size. The trend toward smaller, portable (hand-held), and affordable DF/geolocation systems has and will continue to drive antenna development into smaller form factors, while continuing to provide adequate performance. Finding suitable antenna arrays to fit small platforms or to be portable by soldiers is required for military operations in an environment geared toward mobility. The military and commercial communities are now faced with non-traditional platforms that are severely constrained in available space and weight capacity for payloads, including associated antennas. To overcome these limitations, the U.S. Army seeks to develop new techniques which could use small, compact, lightweight, and wideband single or dual antennae to perform geolocation. These techniques should offer a highly efficient way to locate targets when 'traditional' array based DF systems are not practical due to size, weight, and cost constraints.

The goal of this project is to find innovative methods that will reduce the number of antenna elements needed to do geolocation to one or two elements. The antenna should have sufficient gain to support signal intelligence (SIGINT), and be broadband to reduce the number of antennas needed to cover the frequency range of 20 to 3000 MHz. The antenna should also be compact, lightweight, and small enough to be portable by a soldier.

PHASE I: Develop the antenna designs and identify new approaches (consisting of existing and /or new techniques, methods, and technologies) to perform geolocation with single or dual antenna. Provide a detailed trade study comparing all considered antenna configurations and geolocation techniques and reason for final selection. Demonstrate the feasibility of the selected technique. The Very High Frequency (VHF)/ Ultra High Frequency (UHF) bands are of primary interest for Phase I.

PHASE II: Based on the designs of Phase I, fine tune and develop the final design. Fabricate and deliver prototype antennas along with the algorithm of the geolocation technique(s) selected and used. The deliverables will be tested at the contractor facility and the capability of the prototype will be demonstrated prior to delivery to the Government. Identify potential follow-on work to extend the capabilities of the prototype.

PHASE III: The demand for a geolocation system using smaller, lighter weight, broadband, and low profile antenna is in constant increase in both military and commercial applications. As mentioned above, military use includes all SIGINT and Electronic Warfare (EW) applications such as determining the movements of enemy troops or equipment, locating transmitting antennas associated with various weapon systems, and identifying possible targets for jamming or intercept; whereas potential commercial applications are in law enforcement, search and rescue, boarder control, anti-collision avoidance, merchandise/animal tracking, and amateur radio.

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2) Robert J. Mailloux, "Phased Array Antenna Handbook, Second Edition," Artech House, April 2005.
3) Jung-Chieh Chen; Pangan Ting; Ching-Shyang Maa; Jiunn-Tsair Chen, "Wireless geolocation with TOA/AOA measurements using factor graph and sum-product algorithm," Vehicular Technology Conference, 2004. VTC2004-Fall. 2004 IEEE 60th.
4) Goran M. Djuknic; Robert E. Richton, "Geolocation and assisted GPS," Computer, Volume 34, Issue 2, Feb 2001 Page(s):123 – 125.

KEYWORDS: Single antenna geolocation, antenna design, size and weight constraints, innovative geolocation techniques, sufficient gain, broadband.

A06-111 TITLE: <u>Compact Fast Tunning Direct Digital Synthesizer (DDS) Signal Generator for Electronics Warfare (EW) Jammer Systems</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a compact, fast tuning Direct Digital Synthesizer (DDS) signal generator that is smaller and lower cost then existing units for use as mobile jammer.

DESCRIPTION: Modern EW applications & systems require a Direct Digital Synthesizer (DDS) signal generator module that is faster, has a wider bandwidth, is more power efficient, and smaller than presently available units today. This is especially true for mobile reactive jammer system designs where efficiency, size, and wide output bandwidth on one card are of paramount importance. The development of such a sophisticated tuner technology will greatly advance the EW industry in that it will create jammer applications that formerly were not possible.

The advanced DDS signal generator module should be capable of generating signals from 1 MHz all the way up to 3 GHz. The Device should be packaged in a chassis no larger than 0.25 cubic feet and the DC power consumption must be no greater than 5W. The tuning time between any two frequencies should be less than 3 microseconds and the tuning frequency resolution must be better than 10 Hz. To minimize fratricide, the spurious levels must be better than -40 dBc. Command and control must be high speed. The module must have a Built-In-Test capability and be able to report results of those tests and must be capable of multiple synthesizer channels, all independently controlled.

PHASE I: Provide a feasibility study for Compact Fast Tunning Direct Digital Synthesizer (DDS) Signal Generator for Electronics Warfare (EW) Jammer Systems. Establish systems specifications for signal generator.

PHASE II: Design, build and demonstrate a prototype wideband tuner including the mechanical enclosures. Wideband Tuner tests should be conducted in an environment emulating the intended applications of the tuner. Generate a report showing the result and comparisons to the theoretical model and any deviations from expectations.

PHASE III: The completion of this phase would result in a mature technology, which could be successfully applied to both military and commercial applications such as law enforcement and homeland defense.

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1) Direct Digital Frequency Synthesizers (DDS), Venceslav F. Kroupa.
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KEYWORDS: Electronic Warfare, Jammers, DDS, Radio Frequency, Mobile Jammers, Warlock, Fast Tuning, Compact Package, Programmable, IED

A06-112 TITLE: Advanced Algorithms for Distributed Fusion (A2DF)

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop advanced multi-node, network-centric distributed fusion algorithms and the associated information dissemination architecture/framework and techniques for the integration and synchronization of data from multiple C4ISR fusion systems within a distributed ad hoc networking environment. The developed software would enable efficient sharing and synchronization of sensor fusion data from a variety of Army Intelligence, Surveillance and Reconnaissance (ISR) systems/assets in a distributed network that would provide the Warfighters at various echelons of command a cohesive and updated situational awareness (SA) on threat forces as part of the Common Operational Picture (COP).

DESCRIPTION: In the modern Net-Centric battlefield, there is a need for the development of the next generation intelligence decision support systems among distributed net-centric force structures to provide real-time, relevant situational awareness of the threat forces based on fusion of ISR sensor data from all available sources, to include data from on-board, off-board, and external sensors. To enhance the SA for the mobile commanders and Warfighters, the heterogeneous information fusion in ad hoc networked and distributed environments needs to be considered along with the data aggregation and association. Most of today's advanced Army ISR systems have "Local Fusion" and/or correlation being performed. This creates a complex problem when this data is shared to a Net-Centric environment. The problems occur due to unique identification (ID) not being maintained without understanding the original 'data producer' when there is a receipt of identical reports. Moreover, the problems associated with the transportation of massive amounts of data from individual distributed systems to a centralized fusion center may become the major bottlenecks.

Therefore, the development of innovative, robust, advanced fusion software algorithms and the associated fusion system architecture and that specifically designed to enable C4ISR distributed fusion processes will be the goal of this project. The A2FD software will be developed, implemented, evaluated and tested within a Systems-of-Systems (SoS) modeling and simulation/stimulation environment to demonstrate the degree of scalability and robustness of the developed algorithms and associated architecture in performing fusion in a distributed network environment.

PHASE I: Conduct a study on the Distribution Fusion concepts and identify issues (example: existing fusion algorithms and their applicability in supporting the distributed fusion process, sensor data traffic load, sensor models and Intel systems interfaces, simulation & stimulation environments, communication network: interruptions/delays, node destruction, data management/distribution methodologies, message ID requirements and the effect on distributed data networks, etc.) associated with the data fusion process and related architecture across C4ISR network within realistic battle conditions. This effort will include: consideration of the factors that can affect the minimum performance tradeoff for the overall system in the ad hoc distributed fusion system; explore and describe issues (example: communications, processing, sensor and data, etc.) and solutions associated with the design of the network in reference to the distributed fusion including reliability of links, capacity, etc.; perform analysis to identify the fusion systems and fusion network definition and specify fusion systems for modeling and environmental conditions (ad hoc, distributed, etc.); determine the methods and criteria for the performance measurements.

PHASE II: Propose the technical approach and conceptual design at the top level of the software architecture and development environment (software tools, interface requirements, specifications of input/output data, etc.) in windows (laptop and desktop) based environment. Develop a prototype A2DF software to include: design the Distributed Fusion algorithms and propose a variety of the distributed fusion architecture(s) with the analysis of the performance cost-benefit tradeoff (data completeness and accuracy of the resulting pictures, computational and bandwidth costs, etc.); develop and demonstrate the distributed fusion architecture and software prototype together with the associated development and implementation of the required algorithms and the Graphical User Interface (GUI); test and evaluate the proposed A2DF algorithm and software in a multi-node simulated distributed network scenario. The preferred approach should include using a HLA (High Level Architecture) SoS simulation /stimulation environment.

PHASE III: In Phase III, the prototype A2DF software will be enhanced in real-time performance and expanded for functionality and scalability within the Army RDECOM Modeling Architecture for Technology Research and Experimentation (MATREX) simulation environment with possible transition to key Army Acquisition programs including Distributed Common Ground System-Army (DCGS-A), Future Combat Systems (FCS), and other Future Force programs to be utilized across the Army echelons for threat red force situational awareness applications in support of the mobile commanders and Warfighters. The developed A2DF software, techniques and methodologies may be commercialized to support data fusion processes in ad hoc distributed networks for wireless communications, disaster relief effort, law enforcement operations, etc.

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KEYWORDS: Fusion, Distributed Fusion, Common Operational Picture (COP), ad hoc network, heterogeneous information fusion, Net-Centric environment, C4ISR (Command Control Communications Computer Intelligence Surveillance Reconnaissance) and situation awareness

A06-113 TITLE: Geometric Pairing (GP) of battlefield entities thru the Combat Net Radio System (CNRS)

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop and evaluate an innovative and cost effective Combat Identification (CID) system that will reduce fratricide, increase situational awareness (SA), and enhance combat effectiveness for Soldier-to-Soldier based CID applications. System designs and development will employ signal triangulation techniques such as

Geometric Pairing (GP) technology using Combat Net Radio Systems (CNRS) for determination of soldier position on the battlefield.

DESCRIPTION: Joint, Allied and Coalition forces require a small and lightweight Combat Identification (CID) system that can provide near real time responses for Soldier-to-Soldier identification. The CID system will utilize Geometric Pairing (GP) or other potential triangulation techniques based on Global Position System (GPS) and signal time of arrival to identify the location of battlefield entities. The algorithm is to be employed thru existing Combat Net Radio Systems (CNRS) potentially using the radios themselves as sensors to triangulate individual soldier's position on the battlefield. Based on the time each soldier's radio response is received by a net of radios with known locations, the soldier's position could be identified through traditional triangulation techniques. Laser and GPS based geometric pairing systems are currently being utilized in simulated fire applications to determine whether munitions impact their intended targets. Potentially these geometric pairing techniques could carry over to develop an effective soldier-to-soldier CID solution.

The requirements of the CID system include the ability to provide location and identification of soldiers on the battlefield who are either with or without a GPS receiver. The system must have the capability of determining the location of soldiers in various terrain regions including: forest, Military Operations Urbanized Terrain (MOUT), and desert. It is necessary for the triangulation algorithm to be transportable allowing for interface with other communication systems promoting shared SA capability. Additionally the system should provide a means of tracking entities either entering or leaving the battlefield along with providing an estimation or projection of an entities future position based on their last know trajectory. Contractors should employ methods to reduce hardware size and weight by incorporating advanced electronics and packaging designs as this technology must be carried by dismounted soldiers.

PHASE I: The contractor shall develop an innovative concept for a CID system utilizing triangulation techniques thru Combat Net Radios for soldier-to-soldier identification. Geometric Pairing should be investigated as a potential method to meet the necessary criteria. 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, waveforms, operational and other pertinent issues.

PHASE II: The contractor will develop a prototype and demonstrate the concept that was developed in Phase I. The contractor shall construct a software model to predict and analyze the detailed performance of the system. The contractor shall deliver a prototype of the concept developed in Phase I. The contractor shall demonstrate the system and compare the measured sensor performance against expected sensor performance values resulting from the phase I modeling efforts.

PHASE III: Technologies for friendly identification have a wide variety of application to 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. This system could provide a civilian authority the ability to scan/interrogate an area to determine if any emergency personnel are present.

REFERENCES:
1) Coalition Combat Identification Advanced Concepts Technology Demonstration (CCID ACTD), June 2002, CISC 2002, Pete Glikerdas, Gerardo J. Melendez, PhD, MAJ(P) Kirk T. Allen, & John G. Lalonde.
2) COMBAT IDENTIFICATION CONCEPTS AND CAPABILTIES FOR THE FUTURE ARMY, June 2002, CISC 2002, Gerardo J. Melendez, Ph.D. & Panagiotis (Pete) Glikerdas.
3) Geo-Pairing Based Engagement Simulations for Shoulder-Fired Surface-to-Air Missiles, June 2001, John W. Shockley, Virginia M. Gallagher, & James Y. Gilkey. <http://www.dfirst.com/documents/01E-SIW-075.pdf>

KEYWORDS: fratricide, combat identification, Geometric Pairing, Combat Net Radio Systems (CNRS)

A06-114 TITLE: <u>Uncooled Long-Wave Infrared (LWIR) Hyperspectral Sensor</u>

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: The objective of this SBIR is to develop a compact, low cost, low power Long Wave Infrared (LWIR) hyperspectral or multispectral sensor. This primary use for this sensor will be in the areas of urban warfare and spectral threat detection. Targets will be located at relatively close range (< 1km). The sensor must be adaptable to either ground to ground operations or low altitude unmanned aerial vehicle (UAV) surveillance operations. Emphasis should be placed on using sensor technology that does not require cryogenic cooling. The sensor should split up the LWIR spectrum into a minimum of 10 spectral bands. The noise equivalent spectral radiance (NESR) in each band should be no greater than 1 microflick. If possible, temporal multi/hyperspectral data is desired. It is also desired that the system covert from a standard imaging sensor to multi/hyperspectral sensor and back on demand.

DESCRIPTION: 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 low cost, low power LWIR multispectral or hyperspectral sensor. Therefore, the Army is seeking an innovative, low cost, compact way to obtain a multi/hyperspectral LWIR data. 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, flash detection and identification in complex/urban areas to surgically attack foes, and spectral analysis of potential threat areas for counter Camouflage, Cover, Concealment, Denial and Deception (CCCDD).

PHASE I: Design and demonstrate by analysis a new uncooled LWIR 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 IR FPA, include estimates for the NETD, dark current, and spectral crosstalk if applicable. If the design can switch between imaging and multi/hyperspectral modes, he proposal should include both modeled performance in each case along with a description of the method of conversion between the two imaging modes 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 based upon flash. 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 soil and crop analysis as well as potential stand off chemical analysis.

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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) H. Gumbel, “System Considerations for Hyper/Ultra spectroradiometric Sensors,” Proceedings of SPIE, 2821, pp. 138–170, (1996).
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5) 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, MWIR, LWIR, threat warning, urban environments

A06-115 TITLE: Micro Solid State Low Light Level Camera

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a small size, light weight, low power, solid state silicon TV camera with low light level imaging in the .6-1.0 micron band and or a multi-spectral visible-near infrared (NIR) low lightr level camera with at least 4 bands. Offeror can bid on single color or multi-color separately.

Camera sizes of at least 1280X1024 is desired with imaging in the overcast starlight condition at at least 30 hertz frame rate and input power of no larger than .5 watts. Camera weight shall be no heavier than .5 pounds.

DESCRIPTION: Many scientific, medical and defense imaging applications demand low-light solid-state focal plane sensors that have photon counting sensitivity, megapixel or higher resolution, and hundreds or even thousands of frames per second speed. Some examples include night vision imaging for the soldier, wavefront sensing for Adaptive Optics (AO), real time x-ray imaging for next generation synchrotron sources, security surveillance, and live-cell fluorescence microscopy.

Current state-of-the-art CCDs are capable of delivering near ideal imaging performance with quantum efficiency (QE) approaching 100%, low dark current (3-20 pA/cm2 at room temperature), high linearity and uniformity [1]. However, the serial readout nature of a conventional CCD limits its readout speed. In addition, the finite number of on-chip output amplifiers need to be operated at high speed, and therefore, the CCD read noise could not be easily reduced [2]. This level of read noise seriously compromises the CCD sensitivity at low light level.

Initial efforts to address the noise issue centered upon achieving sufficient electron gain before noise is added down the signal path. Intensified CCDs (ICCD) achieve high signal gain by optically coupling an image intensifier (I2) tube to a conventional CCD. Electron bombarded CCD/CMOS (EBCCD/EBCMOS) sensors eliminate the intensifier phosphor screen and capture the accelerated electrons using the silicon sensor directly. Neither approach is pure solid-state, and all suffer from the inherited limitations of I2 technology that include high excess noise factor, limited lifetime, halo and potential damage from over-exposure, etc.

Alternately, monolithic CCDs utilizing impact ionization to achieve electron multiplication (e.g., Impactron CCD from TI [3] and EMCCD from e2v [4]) show great promise. The impact ionization technique provides a large electric field in a special gain shift register to create charge multiplication wherein a single signal electron can create hundreds of additional signal electrons before they are read out by the output amplifier. In order to provide the multiplication, the camera must provide well-regulated, large clock voltage swings. This requires large amounts of power. EMCCDs are sensitive to clocking induced charge (CIC). At high gain levels, even a small amount of spurious charge can be seen as sharp spikes in the image. In addition, the dark current is amplified along with the signal, effectively lowering the dynamic range of the device. The sensor must be cooled to eliminate any dark signal [4].

The performance of CMOS image sensors has drastically improved over the past decade (see, e.g. [5][6]). Monolithic CMOS image sensors with camera-on-a-chip integration have the potential of providing the ideal size, weight and power solution for man-portable imaging applications. CMOS sensor technology advancements are backed by a vertically integrated industry driven by a much larger consumer market. However, state-of-the-art CMOS image sensors cannot meet the requirements for most low light imaging applications [7]. This SBIR topic is soliciting ideas to overcome the technical issues as discused above.

PHASE I: Using an advanced solid-state night vision camera, develop an alternate architecture for multi-spectral UAV applications. Characterize potential device configurations and perform simulations to optimize the sensor for multi-spectral operation. Develop an ultralight low power camera design for mono color imaging in the .6-1.0 micron band.

PHASE II: Develop a low light level solid-state device providing multi-spectral (visible to NIR) operation and/or a mono color miniature solid state near IR camera (.6-1.0 micron)with less than .5 watts input power. Prototype(s) shall be demonstrated.

PHASE III: Optimize sensor characteristics including power dissipation, read noise, quantum efficiency, and multi-spectral operation to meet UAV payload requirements. The final system will provide multi-spectral imaging in a solid-state solution or a mono color imaging for soldier helmet applications. Solid state low cost camera will be commercialized as a low light level security camera for borders, nuclear power plants, and urban centers.

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KEYWORDS: CCD, CMOS, Lowlight level, solid state

A06-116 TITLE: Improved Far-Target Location Accuracy for Man-Portable Systems Through Application of Micro-Electro-Mechanical Systems (MEMS)-Gyro / Magnetometer Hybrid Sensor & 3-D Compensation Algorithms

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: This research has two primary objectives. First, to develop a prototype hybrid sensor that leverages existing magnetometer technology and augments it with a MEMS Gyro in order to achieve a <.3° (<5mil) azimuth accuracy in the presence of magnetic disturbances typically encountered in a tactical environment. Second, to develop a 3-D Compensation algorithm that takes advantage of the addition of the MEMS-Gyro and provides a more robust and simplified compensation scheme for the prototype sensor, to enable the soldier to employ the device in a wider range of conditions while maintaining accuracy and easing his/her burden.

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 (ref 1). 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. Combining magnetometers and gyroscopes in not a new idea. However, accomplishing this marriage in a package that can be embedded within a man-portable handheld target location system, requires research into new sensor technologies and algorithms which is the focus for this activity. The combination of magnetometers and gyros should improve the overall accuracy and mitigate the error induced by local magnetic disturbances.

Analysis of field reports indicates that the soldiers are having difficultly knowing how to employ these devices to minimize error and executing the complex compensation scheme. The compensation scheme is comprised of a series of bearing measurements. These measurements are run through a complex equation to determine the "best fit" into a virtual sphere. The calculation yields coefficients that are than used to offset the magnetic influence (hard iron effects) of the rest of the device in which the sensor is embedded and to take into account the general orientation of the Earth's magnetic field in that locale. To a degree, these compensation schemes can mitigate local magnetic disturbance caused by vehicles, building, etc. However, the resultant azimuth accuracy is NOT suitable for targeting for effects. The MEMS Gyros are not effected by these disturbances, Also, typical compensation schemes are cumbersome to perform, They require the soldier to manually orient the system in a number of directions and at various orientations to map the local magnetic field in order to generate the needed coefficients. It may be possible to continuously or automatically perform compensation ("auto-cal") to reduce the soldier workload and provide a more robust compensation scheme. Under this research, the compensation algorithms will be further refined to take advantage of the MEMS Gyros and innovative "auto-cal" compensation schemes will be evaluated for their effectiveness and ease of use.

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 magnetic sensors are available in automotive and handheld navigation systems used by outdoor adventurers, and will be explored during this activity. A cost savings may be achieved over current military sources.

PHASE I: Requirements Analysis & Design Study: Requirements for the sensor component (e.g., magnetometers and MEMS Gyros) will be analyzed, defined, and a survey of availability conducted. Once the requirements analysis is complete, selected components will be purchased and tested to determine their suitability. After the key components are identified, the design process will be initiated. A preliminary design of the sensor prototype will be completed and long-lead items authorized, assuming the design is feasible. In addition requirements for the new compensation algorithm will be developed. Once the requirements are defied, they will feed the development of a preliminary architecture for the algorithm. Algorithm design, code re-use, and new code development will be key outputs of the study. Features for improving ease of use will be outlined and users will have an opportunity to input their desires prior to the detailed algorithm design.

PHASE II: Prototype Fabrication and Algorithm Development: During this phase, the prototype design will be completed. A small quantity (<10) prototypes sensors will be built to test and evaluation. Multiple compensation scheme options will be explored in simulation with the most promising being installed on the prototype sensor for test. The prototype sensor and compensation scheme 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 and/or algorithms are suitable for insertion into an ongoing acquisition program like the STORM or TALON programs managed by Product Manager - Soldier Sensors & Lasers (PM-SSL) under Program Executive Office - Soldier (PEO - Soldier).

PHASE III: Technology Transition: Assuming successful completion of Phase II. Additional engineering development prototypes will be fabricated for insertion into a selected acquisition program. The newly updated target location system will be fully tested through traditional Army test and evaluation. If successful, the new target location system will be authorized for full-rate production. Additionally, the test and evaluation information will be shared with the commercial sector enabling "spin-off" into commercial products.

KEYWORDS: Digital Magnetic Compass, Far-Target Location (FTLL), magnetometer, magneto-resistive, magneto-inductive, MEMS Gyro, compass compensation algorithms, azimuth, Target Location Error (TLE)

A06-117 TITLE: Spatial Registration for Forward-Looking Ground Penetrating Radar (GPR) With Magnetometer, Passive Millimeter Wave, Long-Wave Infrared, Medium Wavelength Infrared, Short Wavelength Infrared, or Visible Imaging Sensors

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Research into computationally efficient techniques to perform real-time scene registration of spatial data sets collected from vehicular-mounted sensor assets for counter-mine and counter-Improvised Explosive Devices applications.

DESCRIPTION: Current sensing technologies available for counter-mine/Improvised Explosive Devices and Unexploded Ordnance applications will likely be operated simultaneously from a common vehicular platform to increase overall system effectiveness. Sensor data available from these sensing modalities will need to be spatially registered, either to generate a multi-dimensional data set akin to a multi-spectral image cube, or to have an efficient coordinate transformation to permit rapid slewing of high-resolution interrogation sensors based on cues generated from wide Field Of View detection sensors. This topic seeks proposals for innovative research to address these challenges.

Possible commercial applications beyond the Department of Defense could include: spatial registration of data from vehicular mounted sensors to check for damage and wear to roadways, spatial registration of data from onboard sensors of autonomously controlled passenger vehicles, and spatial registration of data from sensors that are used for access control, such as an access control gate.

For examples of related current work on ground registration, i.e., converting pixel coordinates to ground coordinates, refer to the CERDEC Night Vision Electronic Sensors Directorate's Standoff Mine Detection program (SMDS) with ground penetrating radar and infrared imagery (both single-camera algorithm and stereo imaging). The SMDS program is attempting to detect surface-laid and buried mines with forward looking radar and to map those declarations in Forward Looking InfraRed (FLIR) pixel space. The SMDS program is also addressing side-looking detections using both sensor technologies.

PHASE I: Demonstrate the likelihood that an innovative approach will provide improvement in some meaningful measure of performance.

PHASE II: Develop software modules capable of demonstrating the algorithm at acceptable timelines with representative data.

PHASE III: Transition this software to the work environment of a DoD image analysis or processing environment.

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KEYWORDS: image processing, data compression, image registration, mine detection, Improvised Explosive Devices detection

A06-118 TITLE: <u>High Coefficient of Performance Nano Cooler for Near Room Temperature Detectors</u>

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop solid state coolers using nano technology that can attain very high coefficients of performance. A coefficient of performance of greater than .3 at 280K against an ambient temperature of 350K (includes heat sink rise) and a coefficient of performance (COP) of greater than .1 at 250K against the same heat sink temperature are being sought. Coolers shall be of small size and weight and able to withstand high shock environments. Nanotechnology shall be exploited to make a state of the art increase in device COP.

DESCRIPTION: New Army imaging systems are being developed that can solve the low cost threat warning problem and solve the power and weight problems of putting complex imaging systems on soldier's helmets. The cooler is an important component that must be very low power to enable these new camera concepts to reach fruition. The coolers must be solid state with no moving parts and able to meet the COPs in the objective. Nanotechnology provides a low dimensionality device that can bias the Seebeck coefficient towards a higher value thus increasing the Figure of Merit. Also the thermal conductivity of a low dimensionality solid is reduced, owing to the fact that vibrations face greater difficulty propagating. In this fashion the thermal conductivity is reduced thuis also increasing the figure of merit. Research to date has established that the figure of merit could more than double the current efficiency limit of thermoelectric devices thus making a major breakthroughs for many cooling applications.

PHASE I: Provide material improvements to meet the objectives. Build and test some new material and evaluate its figure of merit.

PHASE II: Build coolers meeting the objectives of the program. Two designs shall be built for cooling to 280K and 250K against a 350K heat sink temperature.

PHASE III: Further optimize the design for military environments. Develop competitive non-freon based commercial refrigeration technology for commercial use. This includes competitive energy efficiency for household refrigeration and air conditioning.

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KEYWORDS: Solid state coolers, thermoelectric, nano, quantum dots

A06-119 TITLE: High Performance Thermal Transfer Material

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Develop high thermal conductivity, low specific gravity material for heat-sinks used in laser designators and focal plane arrays.

DESCRIPTION: Target identification and laser designation is a key objective of the Mission Equipment Package (MEP) for Class II Unmanned Aerial Vehicle (UAV) program, while active 2-dimensional (2D) imaging in the Short Wavelength Infrared (SWIR) waveband is being employed to improve our target identification range beyond the enemy's detection range. These systems require the use of lasers and focal plane arrays requiring temperature control and heat transfer. Materials that minimize the weight of heat transfer components are needed.

Currently, high thermal conductivity materials such as Al, AlN, Cu, CuW, Au, Ag, or diamond are used. These materials have significant drawbacks such as large specific gravity, large thermal expansion coefficient incompatible with most semiconductor and electrooptic materials, requirement for high cost machining techniques, and high bulk material cost.

We seeks proposals for new types of manufactured high thermal conductivity materials with ultra-high conductivity (>1000 W/m K), small thermal anisotropy (<2x), small specific gravity (<2 gm/cm^3), low thermal expansion coefficient (<10 ppm/K). The new material should be compatible with conventional low cost machining and/or molding techniques and should be manufacturable in monolithic pieces measuring up to 6 x 6 x 6" or larger.

PHASE I: Fabricate various thermal materials and perform measurements on intrinsic thermal properties. Demonstrate material compositions that are promising for meeting the program goal of >1000 W/m K thermal conductivity and other material properties described.

PHASE II: Optimize thermal material structure and demonstrate consistent performance. Demonstrate the required thermal and mechanical performance. Fabricate various heatsink and thermal transfer structures specified by Night Vision and Electronic Sensors Directorate (NVESD) for test and evaluation purposes.

PHASE III: High performance thermal materials are required in numerous commercial applications such as heatsinking of high heat load microprocessors used in laptop and desk-top computers, heatsinking of high power microwave components, heatsinking and thermal transfer applications in consumer products such cell phones, and DVD players.

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KEYWORDS: High thermal conductivity materials, heatsinks, thermal transfer

A06-120 TITLE: High Efficiency Erbium/Ytterbium (Er/Yb) Doped Fibers for Eye-safe Fiber Laser Sources

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Develop high efficiency Er/Yb doped double cladding fibers for eye-safe fiber lasers used in compact Light Detection and Ranging (LIDAR) for Unmanned Aerial Vehicles (UAV) and Unmanned Ground Vehicles (UGV) 3D robotics navigation, range-finding, combat identification (ID) and optical free space signal transmission.

DESCRIPTION: Target identification is a key component of the Force Operating Capabilities doctrine to see, understand, and act first. Active two-dimensional (2D) and three-dimensional (3D) Reconnaissance, Surveillance and Target Acquisition (RSTA) sensors are being developed to improve the military's target identification capability. Identifying targets heavily obscured by foliage or camouflage is a key objective of the Mission Equipment Package (MEP) for Class II UAV program, while active 2D imaging in the SWIR waveband is being employed to improve our target identification range beyond the enemy's detection range. One of the most promising optical sources for this application is an eye-safe 1.5 micron fiber laser operating a high PRF of 50 kHz-1 MHz.

Double cladding fibers with Er/Yb doped core are a key component in 1.5 micron fiber laser. The double cladding structure enables generation of high powers through the use of 915-980 nm broad area laser diode pumps. Er/Yb double cladding fibers offer the advantages of insensitivity to wavelength vs. temperature variation and large pump absorption and signal gain per unit fiber length. Best commercially available Er/Yb fibers exhibit a slope efficiency of approximately 40%. The goal of this SBIR is to develop Er/Yb double cladding fibers with a slope efficiency approaching 50%. In addition, the fiber should exhibit high absorption for the pump (>1000 dB/m core absorption

@975 nm), high Er concentration (>40 dB/m absorption at 1535 nm in the core), and low residual gain and ASE at 1 ?m. To ensure compatibility with other types of commonly used optical fibers, the Er/Yb fiber should be have a silica-phosphate glass core and a silica glass inner cladding (NA>0.45) surrounded by a low index polymer outer cladding. For test and evaluation purposes, the fiber should have a 125 micron diameter inner cladding and a core diameter of 8-16 microns. Fiber preform fabrication techniques should be consistent achieving reproducible fiber performance, allow fabrication of sufficiently large performs to allow fabrication of at least several hundred meters of fiber in a single draw, and producing fibers with background losses of <50 dB/km in the core.

PHASE I: Perform a study of the effects of changing core glass composition, Er and Yb concentrations, deposition methods and fiber drawing conditions on the slope efficiency and other properties described. Carry out fluorescence and dopant concentration profile measurements to select the best performs for drawing of test fibers. Carry out measurements of fiber properties jointly with Night Vision and Electronic Sensors Directorate (NVESD) laboratory to determine fiber performance. Demonstrate significant efficiency improvements above that of current commercially available Er/Yb doped double cladding fibers.

PHASE II: Optimize fiber composition and fabrication techniques to consistently achieve a slope efficiency of 50%. Deliver to Night Vision and Electronic Sensors Directorate (NVESD) prototype Er/Yb double cladding fibers exhibiting improved efficiency, and with various geometries designed to optimize fiber laser performance under cw and pulsed conditions.

PHASE III: Fiber lasers utilizing the improved high efficiency fibers would have application to the commercial world as the source for eye-safe terrain mapper or a long-range laser rangefinder, fiber communications systems and fiber-based category 5 (CATV) signal transmission, and free space optical communication systems. Efficient and compact fiber lasers utilizing the new fiber could also be applied to applications such as 3D robotics navigation, obstacle avoidance, or construction site evaluation and monitoring.

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KEYWORDS: Fiber, Er/Yb doped fiber, Fiber Laser, Fiber Amplifier, Short-Pulse Laser, Eyesafe, 3D Imaging, Laser Radar

A06-121 TITLE: High Performance Uncooled Focal Plane Arrays

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To develop and demonstrate innovative low-cost, high performance uncooled infrared focal plane array (FPA) technology. 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. The government is looking for technologies that will provide large improvements in conversion sensitivity and large reductions in noise simultaneously.

DESCRIPTION: Current uncooled IR technology provides an NEDT of 35mK, pixel pitch of 25 micrometers, time constant of 12 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 technologies that can provide a conversion sensitivity of greater than 15%. There are various components of noise including 1/f noise, Johnson noise, and readout noise amongst others. The government is looking for technologies that can reduce or eliminate certain noise sources that will lead to improvements in NEDT.

PHASE I: 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 Integrated 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: 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 variety of commercial applications including transportation, security/law enforcement, medical imaging, border patrol, homeland security as well as military applications such as night vision devices.

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KEYWORDS: Long-wave infrared, uncooled infrared, detector array

A06-122 TITLE: Type I and Type II Superlattices for Tactical Applications

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To provide longwave infrared focal plane arrays and cameras based on type I (Quantum Well Infrared Photodector, QWIP) or type II (Strained Layer Superlattice) superlattice technology.

DESCRIPTION: The advent of Type I (QWIP) and Type II Superlattice (Strained Layer Superlattice) technology provides an interesting alternative to state of the art DoD infrared (IR) sensors, usually based on HgCdTe. The advantages include good bandgap tunability over the infrared and excellent pure-play foundry availability. III-V-based materials have a more mature technology base than current HgCdTe sensors. Additionally, there are large commercial market opportunities. Leveraging advances in superlattice detector technology will have an impact on operability, uniformity and cost. To displace HgCdTe as the infrared sensor of choice, the superlattice must display better uniformity, better operability or higher operating temperature than currently available sensors.

PHASE I: Provide test bars and results from single device testing as a function of temperature of a III-V based superlattice showing performance equivalent to HgCdTe for cutoff wavelengths greater than or equal to 10 microns.

PHASE II: Provide a focal plane array of format at least 256 x 256 based on III-V superlattice technology with a cutoff wavelength of at least 10 microns.

PHASE III: The utilization of III-V starting materials instead of the current state of the art HgCdTe will enable more uniform, less costly focal plane arrays and cameras. By reducing total cost per pixel, these focal plane arrays and cameras could enable new commercial applications such as sensor arrays for high-resolution medical imaging, navigation, and fire/rescue aid."

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KEYWORDS: infrared, photodetector, superlattices

A06-123 TITLE: Innovative Approaches to Service Organization Architectures for Legacy SIGINT System Interoperability with Global Information Grid (GIG)

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Define and develop an intelligent meta-layer for network centric interoperability across C4ISR domain services. The meta-layer will provide a unified access gateway to Global Information Grid (GIG) services regardless of location or service type.

DESCRIPTION: An innovative meta-layer is needed in order to support the integration of legacy systems such as the Army's Guardrail Common Sensor (GRCS) with the GIG. Background: US Army C4ISR (Command, Control, Communications, and Computers, Intelligence, Surveillance, and Reconnaissance) systems are moving toward the network centric objectives established by the DoD in 2003 [Reference 3]. Currently each military component operates systems needed to support their respective war fighting responsibilities; however, the level of effective interoperability between disparate systems is low. GRCS, a critical part of the battle space, is used to gather communications intelligence (COMINT) including emitter characteristics and location. GRCS uses an airborne platform with ground based processing to integrate sensor data for analysis. GRCS is a vertical system with most of its functionality inaccessible outside of the core set of interconnected applications. Operational objectives require that GRCS and other legacy C4ISR systems must interoperate effectively for mission success.

The goal of this SBIR is to develop an innovative meta-layer integration architecture that supports information discovery for available GRCS services. The layer must be structured to provide complete mapping and transformation for data interchange. This applies both to external requests for GRCS services but also to the possibility of GRCS in the role of a service consumer, discovering and utilizing external assets to deliver GRCS functionality. One example of GRCS as a consumer involves the use of GRCS Line of Bearing (LOB) calculations with input from sensors attached to other GIG connected systems. GRCS analysis tools (including graphical map displays) would be available even when the aircraft is not flying by accessing current COMINT sensor data attached to other systems.

Proposals should address the innovations related to the following architectural design features: 1) organization and structure, 2) method of discovery support, and 3) integration into new net-centric enterprise services.

This SBIR topic involves definition of an intelligent meta-layer to include its architectural structure and internal organization. The capabilities of this meta-layer will be demonstrated by a prototype.

PHASE I: Develop technical approach and core innovations for the proposed architectural design. Produce a set of requirements in use case form to capture the core needs of the integration meta-layer.

PHASE II: Design and develop an operational prototype. Conduct demonstrations of the prototype for domain users for comments and evaluation. This prototype's performance characteristics will be assessed against representative throughput measurements established by GRCS. Findings shall be documented in a final report that summarizes the results of the project.

PHASE III DUAL USE APPLICATIONS: Dual use would be applicable wherever there is a need to provide access to a varied set of disparate data services across an enterprise. Army application would include support to the Warfighter through new capabilities that leverage intelligent meta-layer service access to legacy systems such as Guardrail Common Sensor (GRCS) and other new and legacy systems within the GIG. Within the commercial sector, the capability to access enterprise wide services through an intelligent meta-layer would allow for comprehensive intra and inter-enterprise interoperability for systems such as intelligent process modeling and control as well as integrated management control systems and information discovery.

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2. Guardrail Common Sensor Overview: http://www.globalsecurity.org/intell/systems/guardrail.htm (non-Government site)
3. DOD Net-Centric Data Strategy: http://www.afei.org/pdf/ncow/DoD_data_strategy.pdf
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KEYWORDS: Service Discovery; Integration; Interoperability; Data Interchange; Net-Centric

A06-124 TITLE: Innovative Architectures for Flexible Adaptive Communications Intelligence Analysis

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop methods and tools to support harvesting signals intelligence (SIGINT) algorithms from legacy systems for redeployment in modern net-centric environments.

DESCRIPTION: US Army SIGINT programs such as the Guardrail Common Sensor (GRCS) have spanned generational changes in software development and deployment philosophies as well as sensor technologies. Artifacts of each generation become embedded in these systems in a way that makes them difficult to maintain and transport to upgraded architectures and systems. Key analysis algorithms are tightly coupled to internal components and incorporate assumptions that limit their ability to support expanded utilization and interoperability between legacy systems and new net-centric systems. Harvesting these algorithms would allow them to be used outside of their tightly confined solution space. It will also reduce life cycle costs and improve sustainability by reducing dependencies on obsolete hardware and software implementation languages.

A refactored architecture that exposes key algorithms will allow GRCS to continue operation through its projected life span with greater interoperability, as well as aid modern replacement platforms such as the Aerial Common Sensor (ACS). However, the harvesting and refactoring required to realize these benefits is labor-intensive and error prone. The goal of this effort is to develop a methodology and innovative tools that enable the adaptive application of proven SIGINT algorithms. This approach will also be of great benefit to the transition period during which legacy and modernized systems are operating simultaneously.

This SBIR topic involves: 1) development of prototype tools and a supporting methodology, and 2) demonstrating the technical innovation and feasibility by harvesting legacy algorithms from an existing SIGINT system.

PHASE I: Develop and describe the proposed innovation and technical approach for harvesting signals intelligence (SIGINT) algorithms from legacy systems for redeployment in modern net-centric environments. Evaluate the feasibility of the innovation and approach for a selected legacy system, such as GRCS.

Produce a set of requirements in use case form to capture the core needs of a legacy algorithm recovery toolset.

PHASE II: Develop the harvesting methodology, design and develop a prototype toolset, and conduct a demonstration of the prototype. This prototype will be assessed as to its performance and compliance with established net-centric infrastructure elements such as the Distributed Common Ground System (DCGS) Integrated Backbone (DIB). Findings shall be documented in a final report that summarizes the results of the project.

PHASE III DUAL USE APPLICATIONS: Dual use would be applicable wherever there is significant investment in algorithms that are deeply embedded in legacy systems. Army program benefits would be realized by leveraging algorithms from legacy systems such as Guardrail Common Sensor (GRCS) to enhance new systems such as Aerial Common Sensor (ACS) and Distributed Common Ground System - Army (DCGS-A). In the commercial sector, dynamically pluggable and reusable algorithms could be deployed to support multiple applications within highly distributed enterprises.

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2) Guardrail Common Sensor Overview: http://www.globalsecurity.org/intell/systems/guardrail.htm (non-Government site)
3) DOD Net-Centric Data Strategy: http://www.afei.org/pdf/ncow/DoD_data_strategy.pdf
4) Adaptive Architectures: http://www.openwings.org/download/specs/openwingswp.pdf

KEYWORDS: Algorithm; Architecture; COMINT; Interoperability

A06-125 TITLE: Seamless Route Distribution & Management Across Command and Control, Communications, Computers, Intelligence, Sensors and Reconnaissance (C4ISR) Networks

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Develop a dynamic border routing capability to allow seamless interoperability and route management across different autonomous systems. The capability would take care of the scalable route distribution and optimal routing decisions across different routing and administrative domains. Current external gateway routing protocols (EGP), such as Border Gateway Protocol (BGP), do not work well in a wireless environment due to its underlying dependence on stable transmission control protocol (TCP) connections for communication between routing processes and have limitations of interconnecting two autonomous systems at multiple entry/exit points due to the inherent nature of this path vector protocol.

DESCRIPTION: The Future Force architecture consists of several Autonomous Systems (AS). The classic definition of an AS states that an AS is a set of routers under a single technical administration, using an interior gateway protocol (IGP), or multiple IGPs, and common metrics to route packets within the AS and using an exterior gateway protocol to route packets to other AS's. Even when multiple IGPs and metrics are used, the administration of an AS appears to other AS's to have a single coherent interior routing plan and presents a consistent picture of which destinations are reachable through it. The diverse networks that make up the Future Force to include the Warfighter Information Network-Tactical (WIN-T), the Future Combat System (FCS) that consists of Joint Tactical Radio System (JTRS) Cluster 1 and Cluster 5 radios/routers running the Wideband Networking Waveform (WNW) and Soldier Radio Waveform (SRW) respectively, Strategic and Allied Networks would each fall within their own AS due to the varying characteristics, requirements, and performance of these respective systems. To efficiently and effectively route traffic through these varying AS's, a novel approach to border routing is required to meet the challenges of efficient routing across wireless On-the-Move tactical networks, providing multiple entry/exit points for the sake of interconnection survivability and load-balancing, interconnection/healing of splits AS's and interoperability of routing information amongst heterogeneous networks (i.e., varying IGPs, different network layer address families, etc.) without excessive increases in control overhead or other factors that would impact overall network scalability and survivability. The capability should not make any assumptions on the type of IGP running in any particular AS or be IGP dependent. Metrics and other parameters used for IGP routing, i.e. Open Shortest Past First (OSPF) weights or multi-Type of Service (TOS) routing, should be leveraged/translated across AS boundaries, where applicable, to maintain and improve optimal path routing across AS boundaries.

PHASE I: Define a dynamic border routing capability architecture, design plans with identified techniques, algorithms and methodologies. The Phase I effort shall include proof-of-concept implementations and laboratory demonstrations. The result of Phase I must be a high level system design showing the proposed approach. Development and delivery of models and simulations or other methods to analyze the performance of the dynamic border routing capability is encouraged.

PHASE II: Complete the design, development, and demonstration prototype system of the dynamic border routing capability.

PHASE III: Commercial Applications – Mobile Wireless Communications networks, Wireless Sensor Networks. Military Applications – Interconnection of C4ISR Networks to include WIN-T and FCS.

REFERENCES:
1) IETF RFCs - Border Gateway Protocol 4 (BGP-4) RFC 1771, 1773.
2) Linux Route Management Software Zebra/Quagga - www.zebra.org, www.quagga.net.

KEYWORDS: Dynamic Border Routing, Wireless Communications, Modeling and Simulation, On-the-Move communications, Autonomous Systems

A06-126 TITLE: Topology Design and Optimization Tool for Mobile Ad Hoc Networks

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: The objective of this effort is the development of a set of advanced tools that can be used in the automated design of mobile ad hoc networks, such as the Warfighter Information Network-Tactical (WIN-T) or Future Combat System (FCS). This is an engineering tool that can assist engineers in the overall design of ad hoc multi-tiered networks. For purposes of this effort, network design is the problems of connectivity, topological optimization, capacity assignment, and survivability optimization.

DESCRIPTION: Ad Hoc networks for the military environment are characterized by high mobility, link outages, and "random" unplanned topologies. In this challenging environment, it is required that the input requirements for user to user connectivity, end to end throughput and delay, and network path survivability are to be met. A baseline topology results from the operational military movement or location on the battlefield. This baseline topology may or may not provide the desired connectivity, network capacity, or network survivability, since terrestrial multi-hop connectivity, capacity, and survivability are limited by the laws of propagation physics. One way to achieve the desired goals is thru the use of airborne relay platforms.

Thus the network design problem includes first an assessment or estimation of the baseline topology capabilities in terms of connectivity, capacity, and survivability. If the desired goals are not met, then the addition of airborne relay platforms must be added to achieve those goals. It is assumed that airborne platforms have better connectivity to the ground nodes than the ground to ground node links, and that there are far fewer airborne than ground nodes. The number, location, and network capacity of these airborne platforms over the terrestrial multi-hop ground nodes is a major issue in the network design problem in that it directly affects the integrated terrestrial and airborne connectivity, network capacity, and survivability. It may be assumed that the ground nodes number in the 5000 to 10000 range, while the number of airborne platforms is open.

It should be noted that typical inputs to the network design tool should include (but not limited to) an initial set of node locations (determined by military operational goals), assumed mobility pattern or profile, a set of user throughput/delay requirements, a set of radio frequency (RF) transmission characteristics. Additional a (possibility probabilistic) target (goal) value for connectivity and survivability should also be used as input. These inputs are not known at this time, and hence the design tool should be flexible. Furthermore, it is highly desired that the tool be capable of representing the uncertainty in the input values.

The intent of this program is to design and develop a collection of algorithms and/or heuristics that can be developed into a software package. The software developed needs to first perform a real time assessment of the baseline connectivity, and then a recommendation for the addition of airborne Unmanned Aerial Vehicle (UAV) as to number, location, and capability to meet the desired requirements. It is a requirement that the output as produced by the tool lead to an optimal network design. The optimization should be based on a set of input constraints, limits and conditions. The specific class of optimization is left open to the bidder. The tool results should be validated and verified with the results from detailed event driven simulation.

PHASE I: In the first phase, an assessment of currently available ad hoc network design algorithms and/or heuristics is to be performed. Any shortfalls or limitations must be identified, and proposed solutions developed. The results of this phase are to be documented in a technical report that describes the algorithms in a flow chart form and lists all the associated assumptions and/or limitations. It is also highly desired that the algorithms be prototyped and demonstrated in a MATLAB environment.

PHASE II: In Phase II, the algorithms/solutions developed in phase I are to further developed, refined and implemented in prototype software and integrated to provide a solid engineering tool environment. The tool should include a Graphical User Interface (GUI) to allow easy visualization of the network topology and associated input output data. For larger sized networks output files should be generated and be assessable for complete data analysis. The tool should also support and provide sensitivity analysis of the generated output to a range of input values. The network design software shall be used on a number of diverse test scenarios, traffic loading and survivability requirements. The results shall be compared with a detailed, event driven simulation with the same input conditions, and any differences or discrepancies explained.

PHASE III: In Phase III, the tool should be expanded from its Phase II prototype format to be fully functional and supported tool. The tool may be augmented to include highly level functions (i.e., Transport to Application), expanded to handle more diverse sets of user level traffic (such as fractal and self-similar traffic), and more direct interconnected with other simulation technologies.

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KEYWORDS: ad hoc network, network design, topology, connectivity, capacity, survivability

A06-127 TITLE: Dual Band X/Ka On-The-Move Antenna System

TECHNOLOGY AREAS: Sensors, Electronics

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: Initiate the design and development of both X-band and X/Ka dual band Satellite Communications (SATCOM) On-The-Move (OTM) antenna systems which will give the tactical user full advantage of Wideband Gapfiller Systems (WGS).

DESCRIPTION: Currently, commanding vehicles are the most obvious targets in the battle field. The large number of antennas mounted on the vehicle and the profile of these antennas makes the vehicle an important/obvious target. To overcome this issue, two major work areas should be perused. One, reduce the number of antennas by increasing the number of frequency bands a single antenna can support and two, reduce the antenna profile as much as possible. Efforts proposed in this SBIR fall in the first area and focus on a dual band (X/Ka) antenna design. The choice of X/Ka was made to take advantage of the next generation satellites, Wide Gapfiller Systems (WGS). The cross-banding capability of WGS gives the commanding vehicle / tactical user an additional advantage. In a situation where the Ka band commanding vehicle is under weather, it can operate on X band and close a link with other Ka users. Beside reducing the commanding vehicle antenna count, having an X/Ka dual band antenna system will increase reliability SATCOM On-The-Move (OTM) and will give the tactical user access to a more diverse set of satellite Resources. Efforts under this SBIR include the design of an affordable single band antenna that can be upgraded to a dual band in Phase II or later of this SBIR.

PHASE I: Product of Phase I is a design of an affordable X-band On-The-Move antenna that can be upgraded to a dual-band (X/Ka) antenna system.

PHASE II: Products of Phase II include an affordable X-band antenna for OTM SATCOM and a design/plan for upgrading the X-band antenna to a dual band X/Ka antenna system.

PHASE III: The product of Phase III is a dual band X/Ka antenna system for SATCOM OTM applications. Commercial vendors will seize the opportunity to develop this antenna to sell to government customers and they might also use the dual band design ideas for commercial frequency bands.

REFERENCES:
WIN-T Operational Requirements Document (ORD)

KEYWORDS: On-The-Move, SATCOM, dual band antenna, X/Ka

A06-128 TITLE: G-Hardened Radio Hardware Technology

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

OBJECTIVE: This program will develop radios and communication hardware for existing disc-like sensor nodes that are capable of forming a scalable ground-based sensor field. Communications for these intelligent nodes should be optimized for maximum energy efficiency, bandwidth, scalability, security, geo-location and other desired network attributes to provide the Warfighter with the state-of-the-art situational awareness. Desired disc attributes should be confined to less than a 40mm diameter with less than a 3in height. Because of the rugged handling and distribution requirements, radio hardware should withstand at least 20,000g's of force. Packaging of nodes will take into account existing sensor hardware that must be form fit to accommodate size, weight and power constraints of a sensor package developed for the 40mm form factor. Weight distribution of nodes should be ideally uniform within a minimal centroid for the aspect of handling and distribution of existing sensor hardware. Weight distribution of nodes should be ideally uniform within a minimal centroid for the aspect of handling and distribution. Each node will have GPS capability for identifying the location of the sensor event. An external gateway node(s) may be required to transmit this information back to a remote user. Information on particular details (e.g. sensor interface) will be provided upon award.

DESCRIPTION: Commercial sensor radios that needs to evolve from laboratory concepts to meet with tactical requirements for field use. With the evolution of packaging technologies and miniaturization of devices components, there is tremendous focus to reduce the weight bearing load for distribution of these sensors in the battlefield. Special attention to communications is required to reduce the number of the nodes and maximizing network throughput and therefore effectively enhancing sensor ranges to result in an optimal cost solution for number of sensors per unit area.

PHASE I: This effort shall design a sensor network with the aforementioned attributes. This will include adherence to tactical operational environments with attention to Size, Weight and Power (SWaP) for and an existing sensor/packaging design and resistance to high g conditions (20,000g). The network is expected to quickly establish itself with intelligence to monitor and relay sensor information effectively and securely during its duration of deployment. Nodes are expect to maintain connectivity for a minimum of 30 days. An initial experimental validation with the desired attributes of the sensor network is highly encouraged (10-12 nodes). Collaboration with DoD industry is encouraged to facilitate future transition.

PHASE II: The goal of this Phase II shall focus on the delivery of 100 sensor nodes in a practical experimental setting. Minimal technology readiness level (TRL) of 5/6 is required upon completion. Partnership with DoD industry is highly desired to be solidified during this phase.

PHASE III: The results of the Phase II should transition to Phase III production with the appropriate development team. The development of these rugged sensor nodes can lead to applications for homeland security, commercial shipping distribution, environmental monitoring, production quality control, food processing, and a myriad of wireless applications.

REFERENCES: Many references in the public domain are available for sensor networking technology (e.g., MILCOM 2005 - Charles J. Graff, US Army RDECOM - various papers). The key aspect is the enhanced survivability of these nodes when experiencing external forces of 20,000g's. Current commercial "micro-motes" manufacturers must take into account their current designs for this design parameter. Also, packaging design should include size, weight, and power constraints (SWaP). The other aspect is the network hardware and "smarts" to cover a greater area for a longer duration of time. By maximizing these parameters, one obtain an potential cost-effective solution for the Army.

KEYWORDS: sensor networks, micromotes, manufacturing technologies, packaging technologies, intelligent munitions, manuever support, ad-hoc sensors networks, wireless graph theory, biological inspired networks, energy conservation, hardened components, network science, integrated sensors and communication, JTRS Cluster 5, sensor waveforms, nanotechnology

A06-129 TITLE: Programmable Waveform-Independent Digital Processor for Digital-RF Satellite Communications

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Enterprise Information Systems

OBJECTIVE: To develop low cost programmable waveform-independent digital processor modules for wideband satellite communication.

DESCRIPTION: Multi-band, multi-channel Satellite Communication (SATCOM) systems are currently being developed utilizing the direct conversion transceiver architecture. This architecture, enabled by wideband analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) running at clock speeds from 20-100 GHz, eliminates all analog up-down converters, splitters, combiners, etc., and reduces terminal space and cost. The direct conversion architecture requires high-speed digital processors to handle these digitized Radio Frequency (RF) signals at very high rates. One possibility is to partition the signal processing in two steps. First an ultrafast digital processor, running at the data converter clock speed of 20-100 GHz, interfaces directly with RF ADCs and DACs and reduces the data rates down to 100-1000 Msample/s. Then a slower, more complex, digital processor, operating on the reduced data rate, takes over and performs the rest of the processing, including Modulation-Demodulation (MODEM) functions. Efforts are under way to realize the first step utilizing ultrafast digital circuits, for example using superconductor microelectronics. This topic will propose to provide cost-effective solutions for the second step, preferably using commercial Field Programmable Gate Arrays (FPGAs), to meet the needs of a variety of SATCOM systems, both strategic and tactical. The proposed processor will need to interface with the faster digital circuits, perform digital channelizing functions, and host digital modems for each channel. The goal is to build a universal processor that is independent of specific waveforms. The programmable waveform-independent processor will be designed as a universal, digital signal processor that is independent of specific waveforms. Sample applications that could be hosted on this processor include digital channelization functions, data modulation/demodulation, spectrum monitoring and control, signal identification and analysis, link performance measurement and analysis, and interference mitigation.

PHASE I: Develop a digital processor scheme by utilizing FPGAs for interfacing with and processing with ultrafast directly digitized RF data for satellite communication. In addition, the digital processor should perform digital channelizing functions and host digital modems for each channel for any standard MILSATCOM waveform.

PHASE II: The phase II deliverable will be a digital processor module, to be tested and evaluated as part of the direct conversion satellite communication architecture, by demonstrating its interoperability with standard military satellite signals in X-band and Ka-band.

PHASE III: Potential military applications are the next generation strategic and tactical satellite communication systems, such as the Modernized Enterprise Terminals (MET), and other tactical wireless communication systems, such as the Joint Tactical Radio Systems (JTRS). The technology will also apply to commercial satellite and wireless communications, such as commercial earth stations and wireless cellular base stations.

REFERENCES:
1) D. Gupta O. Mukhanov, A. Kadin, J. Rosa, and D. Nicholson, “Benefits of superconductive Digital-RF transceiver technology to future wireless systems,” in Proc. of the SDR Technical Conference, San Diego, vol. I, pp. 221-226, Nov. 2002.
2) R. H. Walden, "Analog-to-digital converter survey and analysis", IEEE J. Selected Areas in Commun., vol. 17, pp. 539-550, Apr. 1999.

KEYWORDS: MILSATCOM RF Signal, Ultra-fast Digital-RF Conversion, Baseband Digital Signal Processor, MODEM

A06-130 TITLE: Spatially Combined Metamorphic High Electron Mobility Transistor Power Amplifiersfor Satellite Communications

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: To develop high efficiency, spatially combined mHEMT power amplifiers for on-the-move SATCOM applications.

DESCRIPTION: Current on-the-move SATCOM antenna systems have low power added efficiency (~15%) and resulting high cooling requirements which preclude their use on tactical systems. Performance enhancements provided by technologies such as spatial power combining and mHEMT MMIC (monolithic microwave integrated circuit) amplifiers will enable the design and fabrication of amplifiers with power outputs of >10 watts at Ka Band with a 30% power added efficiency. The power added efficiency is critical due to the mounting of the power amplifier on the dish antenna contained within a sealed radome. This makes heat extraction difficult.

PHASE I: The Phase I effort will result in the analysis and design of new high (~30%) power added efficiency power amplifiers at 29.5-31 GHz with a power output of 10 watts at 1 dB compression. Spectral regrowth at the 1 dB compression point will be -30 dBc @1.5 SR, per MIL-STD-188-164A. Extendibility of the technologies to 43.5 to 45.5 GHz will also be shown. Technologies considered shall include, but not be limited to, spatial power combining and mHEMT MMIC amplifiers.

PHASE II: The Phase I designs will be utilized to fabricate, test and evaluate the initial high efficiency power amplifiers. The designs will then be modified as necessary to produce the final prototypes. The final delivered 30-31 GHz and 43.5-45.5 GHz amplifier prototypes will be demonstrated to highlight the power added efficiency and spectral regrowth at the rated 1 dB compression power level of 10 Watts.

PHASE III: Program Manager, Warfighter Information Network-Tactical (PM WIN-T) and Future Combat Systems (FCS) programs for tactical on-the-move SATCOM antennas. Commercial on-the-move communications antennas for high data rate communications for Land Mobile Distribution Systems as well as automotive and marine markets.

REFERENCES:
1) "Progress in GaAs Metamorphic HEMT Technology for Microwave Applications", P.M. Smith et al, 2003 IEEE GaAs Digest

2) http://www.wavestream.com/downloads/tech_focus.pdf "Tech Focus: Spatial Power Combining"

KEYWORDS: Power Amplifiers, mHEMT, MMIC, SATCOM antenna, spatial power combining

A06-131 TITLE: Routing Protocol Design Toolset for Wireless Ad Hoc Networks to Maximize Quality of Service

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: This SBIR program will be developing a routing protocol design toolset (RPDT) that will allow selection of available routing protocol components and provide a set of values for the tunable parameters based on network design goal inputs for heterogeneous networks. The design goal input to this tool shall be general set of overall network requirements, such as Quality of Service, network mobility, network failures, network congestions and available application traffic profiles. The output of the design tool shall be a set of tunable parameters and general protocol requirements that are used for the selection of both Unicast and Multicast Mobile Ad-Hoc Network (MANET) routing protocols from a set of available routing protocol components or development of new protocol from a set of available routing components. This SBIR is focused on working with the routing layer of the Transmission Control Protocol/Internet Protocol (TCP/IP) protocol stack.

DESCRIPTION: The demand for Quality of Service in commercial and military mobile ad hoc networks is growing at a rapid speed. To provide this quality of service, current networks are over-laid with trial and error or some simulation based routing and quality of service protocols that do not offer the optimum network wide performance. This innovative research will be developing formal design tool having network models, techniques and methodologies for the selection of routing protocol components and development of formal design requirements along with providing values for tunable parameters that provide the optimal performance for a set of network goals. The innovativeness of this research is in the area of component performance monitoring and comparison based on given set of network goals. This means developing component comparative metrics and models. The design tool shall consider all the relevant information requirements inputs from physical, data link, network, transport and application layers with the goal of providing routing protocol components that will satisfy network wide quality of service in a network failure and network congestion conditions. This design tool shall also be able to provide optimal values for the tunable parameters for the routing protocol that a user chooses to utilize in a given network. For example, a network planner chooses to run an OSPF(Open Short Path First)v3 on the MANET network for unicast traffic and PIM-SM (Protocol Independent Multicast-Sparse Mode) protocol for multicast traffic. This tool shall be able to provide the network planner with all the settable values for OPSFv3 and PIM-SM to perform optimal under given scenario. This feature of the design tool allows users to work with existing protocols, but getting the most performance results. Under different set of condition, a network planner may not have any particular routing protocol in mind, but utilizes this tool to obtain a list of possible routing protocols and components.

The RPDT tool will be supporting the Network Design program, the Multi-Dimensional, Assured, Robust Communications for On-the-move Network-i (MARCON-i) Army Technology Objective (ATO) and the Future Combat Systems (FCS) program. All dealing with dynamic wireless mobile network environment having heterogeneous network links. In this environment the network nodes are all wireless nodes and can have multiple front end radio frequency (RF) links. This includes diverse RF links such as high bandwidth links, low bandwidth links, satellite links, etc. all of which would be available at each of the mobile network nodes. All nodes are assumed to be mobile at any time. There is no fixed stationary communications network infrastructure. Network traffic type to be assumed is Voice Over Internet Protocal (VoIP), data and video utilizing either unicast, multicast or broadcast modes.

The commercial application for this design tool can be realized in mobile ad hoc networks with no infrastructure. For instance in a disaster relief effort by the first responders.

Key performance parameters output for the routing protocol from the RPDT tool can become the input for modeling and simulation tool for V&V (verification and validation) purpose. The tool shall be able to handle network having 1000s of nodes and network layer security such as IPsec.

PHASE I: This effort will entail a preliminary RPDT architecture, RPDT design plans with identified techniques, algorithms and methodologies. Relevant experimentation suitable for feasibility of practical implementation of the design tool. Innovative and mature techniques, algorithms and mathematical models from all areas of network protocols are encouraged. The Phase I effort can include proof-of-concept implementations and laboratory demonstrations. All types of trade-off analyses are encouraged. The result of Phase I must be a high level system design showing all proposed approaches and their interaction. Proof-of-concept demonstration is required.

PHASE II: This effort shall fully implement the RPDT tool as outlined in Phase I. It shall also include the porting, characterization, testing, and lab demonstration of the implemented design tool. The overall goal is to fully develop the design tool that can be verified with modeling and simulation tool and/or a small network simulation with relevant nodes.

PHASE III/DUAL USE APPLICATIONS: Mobile telecommunication networks for Commerce and Homeland Defense, mobile sensor networks. Ad hoc network for the first responders. Military Applications: MARCON-I, WIN-T, JTRS, Sensor networking, Future Combat System (FCS), Unattended Ground Sensors.

REFERENCES:

1) CERDEC Network Design Program.
2) CERDEC Multi-Dimensional, Assured, Robust Communications for On-the-move Network-i (MARCON-i) STO Program, Warfighter Information Network-Tactical (WIN-T) Program, Future Combat System (FCS) Program.
3) Classification of Components and Approaches of Ad Hoc Routing Protocols. PPT presentation dated Oct 22, 2004 by Myung Lee and Tarek Saadawi at City College of New York.
4) Bottom-up cross-layer optimization for mobile ad hoc networks, Xinsheng Xia and Qilian Ling at the Department of Electrical Engineering in The University of Texas at Arlington. From IEEE proceedings MILCOM 2005, October 2005.
5) Network Visualization and Analysis tool based on logical network abridgement, University of Birmingham, UK and Ideas Network Ltd. From IEEE proceedings MILCOM 2005, October 2005.
6) Designing fault tolerant ad hoc networks, Information Technology R&D Center at Mitsubishi Electric Corp, Japan. From IEEE proceedings MILCOM 2005, October 2005.

KEYWORDS: Mobile Ad- Hoc Network (MANET) Design, Component based routing, Agent Based Technology, On-the-Move communications, Cross-Layer Design Optimization, Multi-layer protocols, Quality of Service Protocols, MANET Unicast Routing, MANET Multicast routing, Network Layer Protocol

A06-132 TITLE: Curved Surface Electromagnetic Band Gap Metamaterial

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Improve antenna performance through the use of curved surface electromagnetic band gap (EBG) metamaterial, which promises to reduce the mutual coupling between antennas, improve radiation efficiency of low profile antennas, or reduce electromagnetic interference (EMI) between components.

DESCRIPTION: Electromagnetic band gap (EBG) metamaterial offers pass and stop bands to electromagnetic waves that can provide a lossless, reactive surface that inhibits the flow of tangential electric surface current. Recently it has been shown that metamaterials can prevent propagation of surface directed radiation on planar structures. This can be extremely useful when trying to minimize mutual coupling between antennas, improve radiation efficiency of low profile antennas, or reduce EMI between components.

The design and implementation of EBG metamaterial have been focused on planar structures, and EBG metamaterial with substructures of planar and periodic forms may not fit to a curved surface and retain its desired electromagnetic properties.

There are many applications for conformal/curved surface antennas, such as for air platforms, where aerodynamics is critical, and body worn antennas. It is unknown whether EBG metamaterials can be effective in conformal/curved surface applications. In particular, the question of whether the simple design formula used for planar EBG metamaterial can be utilized in a curved surface environment or whether full-wave analysis tools, such as finite element method or finite difference time domain techniques, are required, need to be determined.

PHASE I: Provide an initial analysis of the application of curved surface electromagnetic band gap (EBG) metamaterial to antennas, in regards to minimizing the mutual coupling between antennas, improving radiation efficiency of low profile antennas, and reducing EMI between components.

PHASE II: Complete the analysis of the application of curved surface EBG metamaterial to antennas. Prototype and characterize an EBG metamaterial for a curved surface application. Design and prototype a conformal antenna system for a curved surface vehicular application using an EBG metamaterial. The antenna system should have an omni-direction horizontal gain pattern in the frequency range of 400 MHz to 1,000 MHz. Deliver two prototypes of the conformal antenna systems. Provide a final report documenting the analysis, design and construction of the conformal antenna system.

PHASE III: Advanced antenna design can be used to improve communication and vehicle performance on multitude of both military and commercial platforms. Some applications are: various military platforms including tank, Unmanned Aerial Vehicle (UAV), and FCS Program use the conformal antenna with reduced form-factor, and weight to improve the survivability and performance of FCS platforms. Commercially, the aviation, automotive, and marine industries with ever greater number of wireless system on board their vehicles would be interest in technology for improve antenna systems that do not have a negative impact on the aesthetics and aerodynamics/performance of their products.

REFERENCES:
1) K. Sarabandi and H. Mosallaei, “Novel artificial embedded circuit meta-material for design of tunable electro-ferromagnetic permeability medium,” Microwave Symposium Digest, 2003 IEEE MTT-S International, Volume: 3, 8-13 June 2003.

KEYWORDS: Metamaterial, antenna, curved, conformal, communication

A06-133 TITLE: <u>Multi-Mode Acoustic/Radio Frequency (RF) Techniques for Sensor Node Localization and Building Characterization</u>

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The objective of this effort is the development of a set of advanced network algorithms and implement on a set of low cost, disposable sensor radio/motes. Sensor motes can be used to characterize the interior of buildings for the purposes providing Future Combat System (FCS) war fighters with a standoff Situational Awareness (SA) capability.

DESCRIPTION: Future Combat War Fighters face unknown adversaries that rely on our lack of SA to conduct insurgent operations. War fighters are faced with the challenge of entering urban environments where the potential for large casualties and fratricide exists due to fighting the “unknown”. Therefore the need exists for small, low cost and robust unattended ground sensor (UGS) that utilizes multiple RF/acoustic sensing technologies, to perform indirect viewing “characterization”, surveillance, and situational awareness against mounted/dismounted threats within an urban environment.

Such a characterization could be made through the hasty deployment of an inexpensive sensor network by clearing or responding personnel where operational circumstances (stress, smoke, fire) prevent them from assessing room placement and dimensionality themselves. Such an ad-hoc network could be formed by deploying small, low cost sensor radio/motes within a building by clearing (or responding) personnel during their operation.

A partial characterization could be derived from knowing the relative location of each sensor node and the connective topology that results from the formation of the RF network. It is permissible to use a few Global Positioning System (GPS) located nodes external to the building, to “anchor” the network’s geographical location.

This characterization could be enhanced by using a combination of ultrasound sounders and detectors in each sensor node to form a connected acoustic ad-hoc network. These sounders and detectors could be coordinated via the RF network to both determine node adjacency and, via the relative slow acoustic sound velocity, the dimensionality of their containing rooms. From this size and adjacency information, the interior layout can be determined.

The determined layout is to be displayed graphically in such a way that it can be readily interpreted by clearing or responding personnel.

This SBIR is to develop the building interior network algorithms and implement them on a set of small, low cost sensor/radio motes. In addition, a Graphical User Interface (GUI) is to be developed to interpret the collected data. The contractor is to demonstrate capability by deploy the system in urban environment, write a report detailing the algorithms, their design, and implementation (including source code), and deliver a complete system to Space and Terrestrial Communications Directorate (STCD).

PHASE I: In the first phase, an assessment of currently available ad hoc network designs, RF and Acoustic localization algorithms and/or heuristics is to be performed. After detailed literature survey and assessment any shortfalls or limitations must be identified, and initial set of algorithms solutions developed. The results of this phase are to be documented in a technical report that describes the algorithms in a flow chart form and lists all the associated assumptions and/or limitations. Develop detailed simulation of these algorithms and assess theoretical performance capabilities.

PHASE II: In Phase II, the algorithms/solutions developed in phase I are to further developed, refined and implemented in prototype hardware. Develop limited prototype nodes (10-15) based on existing technology base. Hardware and software is to be integrated to create a system that demonstrates building characterization capabilities. The prototype system should include a GUI interface to allow easy visualization of the network topology and associated sensor input data. GUI should provide 3d visualization of interior as they are developed. Solution should characterize individual areas (such a single room), and be able to expand to capture multiple areas (multi room visualization i.e., floor plan). The results shall be compared with a detailed, event driven simulation with the same input conditions, and any differences or discrepancies explained. Prototype nodes will be field tested in small scale demonstration to validate simulation and show operational effectiveness.

PHASE III: Military and law enforcement will be able to capitalize on building characterization applications. This technology can be applied to homeland defense applications. It can be used in a wide variety of urban operations to provide security and SA for critical structures such as seized/occupied building to nuclear power plants. In Phase III, the ad-hoc networking system (30-50) should be expanded from its Phase II prototype format to be a fully functional and supported network system. A complete system will be delivered to STCD to promote transition strategy to War Fighter Program Offices. System should leverage from Phase II to expand characterization from room to room, to floor to floor thus given a greater picture and confidence level of building.

REFERENCES:
1) L. Girod, D. Estrin, "Robust Range Estimation Using Acoustic and Multimodal Sensing" In submission to IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2001) , Maui, Hawaii, October 2001.
2) N. B. Priyantha, A. Chakraborty, H. Balakrishnan, "The Cricket Location-Support System," Proceedings of the Sixth Annual ACM International Conference on Mobile Computing and Networking (MOBICOM), August 2000.
3) L. Girod, "Development and Characterization of an Acoustic Rangefinder" USC-CS-TR-00-728, 2000.
4) A. Ward, A. Jones, A. Hopper, "A New Location Technique for the Active Office," IEEE Personal Communications, Vol. 4, No. 5, October 1997, pp 42-47.

KEYWORDS: RF, Acoustic, communications, Ad-hoc networks, MANET

A06-134 TITLE: A Man-Portable Fraunhofer Line Discriminator/Spectrometer

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective of this SBIR is to study the feasibility of and to design and build a prototype Fraunhofer Line Discriminator-Spectrometer (FLD-S) capable of sub-angstrom remote sensing of fluorescence emissions in discreet dark solar bands. The instrument is intended to be man-portable (conforming to FCS requirements for low power) for the measurement of various chemical, biological, and radiological contaminants and their associated materials or other environmental effects using the Fraunhofer Line-Depth method or similar. Information gathered from this sensing strategy would directly feed battlespace terrain reasoning and awareness (BTRA) and potentially augment existing sensing and collection systems.

DESCRIPTION: Active laser induced fluorescence has been shown to be an effective remote sensing technology for biological, chemical, and radiological threats. However, a disadvantage with this technology is that it must be conducted in darkfield (darkness) on specific targets or by the use of taggants to label specific targets. This operationally challenges the technology by limiting its use to night time operations. As an alternative, passive fluorescence takes advantage of the Sun to provide the illumination necessary to excite fluorescent targets instead of a laser. Passive fluorescence can be used to remotely sense battlefield contaminants where molecular species or radiologicals have emissions occurring within the discreet dark bands of the solar photosphere. These regions of absorption, or Fraunhofer Lines, are dark regions in the solar spectrum caused by selective absorption of radiation by (periodic) gases and elements above the solar photosphere. These known absorption lines offer a window of opportunity to observe remotely sensed fluorescence emissions in daylight (using the Sun as an excitation source). This is seen as an extreme advantage over dark-field, laser-induced luminescence measurements. To accomplish Fraunhofer measurements, a technique commonly referred to as the Fraunhofer Line Depth or Fraunhofer Line Discriminator (FLD) method is used with an instrument capable of sub-angstrom operation. Knowing that these regions of the solar spectrum are dark, or near dark, luminescence can be calculated using a simple algebraic ratio similar to that used for reflectance (hyperspectral) measurements. Measurement of luminescence using Fraunhofer lines typically involves observing a non-fluorescent material such as a halon or spectralon standard, and the target fluorescent material, at the center of the Fraunhofer line, and at the continuum, a few Angstroms from the line. Reflectivity differences are typically negligible across a few Angstroms, so the luminescence coefficient can be calculated effectively giving rise to the target emission spectra. Battlefield targets of interest include tagged explosives, plant stress due to defoliants or insult, chemicals, and labeled and un-labeled biological materials.

PHASE I: Demonstrate the feasibility and provide modeling evidence for the signal recovery of organic fluorophores using specific Fraunhofer Lines (e.g., Lines C (H), D (Na), and F (H II)). Perform a detailed evaluation on such an instrument’s operational value in the detection of chemical, biological, and radiological constituents including highly volatile materials (Sarin analogues such as DMMP or ancillary indicators), biologicals including media constituents like aromatic amino acids and dipicolinic acid, labeled as well as un-labeled targets, and radiological fluorophores including uranyl species. Feasibility should include any associated measurements related to operational / tactical battlefield environment.

PHASE II: Design and build a prototype FLD-S and demonstrate its use and accuracy for sensing targets described in Phase I under the feasibility analysis. Assess the utility of the instrument and it’s value-added to current sensor collection systems. Measure the success or failure of the prototype against performance metrics that include: 1) resolution (.5 Å or better), 2) automation and calibration against a NIST standard, 3) computation of FLD method for line “fill-in,” 4) interference and background noise subtraction and consideration in modeling final spectra.

PHASE III: Applications for such a sensor are related to environmental assessment of toxic wastes and pollutants. An advantage of such a stand-off device is the operational flexibility to observe fluorescence emissions of targets without the aide of lasers or external high-power light sources.

REFERENCES:
1) J. Grainger and J. Ring. “Anomalous Fraunhofer Line Profiles.” Nature 193: 762, September 1962.

2) J. Grainger and J. Ring. “Lunar Luminescence and Solar Radiation.” Space Research 3: 989-996, July 1962.

3) Plascyk, J. A. “The MK II Fraunhofer Line Discriminator (FLD-II) for Airborne and Orbital Remote Sensing of Solar-Stimulated Luminescence.” Optical Engineering 14(4): 339-346. May 1975.

4) C. Sioris, G. Corregous-Lacoste, M. Phillipe-Stoll. Filling in of Fraunhofer Lines by plant fluorescence: Stimulations for a nadir-viewing dsatellite borne instrument. v. 108 p. 31 - 36. February 2003.002.

KEYWORDS: Fraunhofer Lines, passive fluorescence, dark solar regions, Fraunhofer Line Depth

A06-135 TITLE: Developing Automated/Semi-automated Techniques to Align Vector and Image Data

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop automated/semi-automated techniques to align vector and image raster data.

DESCRIPTION: As the availability increases of geospatial data (both vector and raster), there is a pressing need to match these data sets together. However, since these data sets often vary in their origins and spatial accuracy, they often do not match well to each other. This lack of spatial correspondence creates problems. For example, from a visualization perspective, vectors often will not line up with the background imagery. This leads geospatial analysts to question the veracity of the spatial data – either one or both is spatially inaccurate. For modeling and simulation, it is essential that both the vector and image datasets are aligned geospatially. In addition, the spatial mis-registration of datasets can also lead to errors in spatial analysis. To get the existing vector data to accurately match up with imagery, analysts now either have to: 1) manually move the vectors, 2) perform a labor-intensive spatial registration of vectors to imagery, 3) move imagery to vectors (rubbersheet), or 4) redigitize the vectors from scratch and transfer the attributes. All of these are time consuming operations and labor-intensive.

Matching and fusing vector datasets together has been a subject of research for many years and strides are being made. This type of fusion is called vector-to-vector conflation. However, much less research has been done with matching or fusing between vector and raster data - i.e. vector-to-image conflation. While there are initial forays into this research area, the approaches are not nearly robust or commercially available. This SBIR intends to address this research shortfall. Specifically, automated/semi-automated techniques need to be developed to conflate vector and image data.

The SBIR’s objective is to design and build software that will conflate vector and image data in a automated/semi-automated manner. While the goal is total automation, it is recognized that this may not be possible. However, a semi-automated approach must be able to significantly reduce the manual steps and time necessary to align the vector and imagery data. The software must minimally be able to perform the following: 1) allow conflation to be performed in either direction (vector-to-image or image-to-vector; however, vector-to-image is the priority), 2) work with road vectors, 3) work with feature vectors and imagery where the spatial displacement is non-systematic (i.e. a simple translation will not suffice), 4) work with both panchromatic and multi-spectral imagery, 5) work with high-resolution imagery (4 meter and better), 6) move all corresponding vector data layers even if matching and conflation are only based on one vector data set (for example, if road vectors are matched and conflated to imagery, move all corresponding ancillary vector layers along with the roads), and 7) make analyst approved changes persistent (i.e. conflation is not just for real-time display).

PHASE I: The contractor needs to accomplish two research goals using Government provided vector and imagery test data. First, develop a methodology and preliminary software design that would perform vector-to-raster conflation. The contractor would have to state specifically in this design how he intends to perform the conflation and with what (if any) COTS software. While the Army prefers that the proposed solution be compatible with ESRI (ArcGIS) or LEICA (ERDAS IMAGINE), the Army will consider others. The design will also have to specifically deal with the issue of non-systematic spatial displacement. Second, using test data provided by the Government, the contractor must demonstrate a basic capability to perform automated/semi-automated vector-to-image conflation. The vectors to be conflated will be a road network.

PHASE II: The contractor will complete the system design and develop the processing capabilities that are defined in Phase I as a prototype system. The prototype system will further develop and enhance the capabilities developed in Phase I. Testing will occur with as much data as time and budgetary constraints allow. Tests should progress from easier to more difficult – for example, migrate from suburban to heavily urban areas. Testing will progress with data provided by the Government. Software must be able to ingest and export standard data formats for imagery and vector data.

PHASE III: This SBIR would result in a technology with broad applications in the military and civil communities. Sources of commercial imagery data, especially high-resolution imagery, will continue to increase. This imagery is expected to be registered to the ground very well through rigorous photogrammetric approaches. There will be large amounts of vector data, especially historical vector data, that will not be aligned well to this high-resolution imagery. Vector-to-image conflation software will need to be developed to bridge this gap. Other Governmental agencies, such as the USGS, have a need for this type of capability – i.e. to match up USGS digital DOQ's with their digital line graph (DLG) products. The Homeland Security community could also benefit from this technology. As more vector and image data – especially high-resolution imagery – becomes available for U.S. cities, this data will all have to be co-registered to each other to maximize its utility.

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KEYWORDS: conflation, register, raster, vector, semi-automated

A06-136 TITLE: Three Dimensional (3D) Topology Builder

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: The objective of this SBIR is to develop software which will build, validate, edit, query, and display ISO 19107-compliant three dimensional (3D) geometry and 3D topology on geospatial data from a variety of input sources.

DESCRIPTION: The problem: Urban warfare poses unique challenges for the Future Combat System (FCS) and other army systems, which need detailed knowledge of this complex, dynamic battlespace. Operations in complex and urban terrain require three-dimensional (3D) geospatial data to represent complicated urban landscapes and relationships between objects, both above and below the ground. Spatial relationships involving interior, exterior, above, and below are all very important in a dense urban battleground. Mission planning in an urban setting requires the representation of building exteriors – their walls, windows, and roofs; building interiors – their rooms, doors, and corridors; subterranean structures and passages; and the interconnected relationships of all these spatial objects. For instance, urban line-of-sight tools needs to penetrate windows into the interiors of buildings, rather than simply dealing with windowless surfaces. Similarly, an urban rescue operation for a dismounted Army soldier involves 3D maneuvering through hostile or burning buildings – through streets and subterranean passages.

This topic does not address the needs of the modeling and simulation community or of the CAD community. This topic addresses the needs of the mapping community. In the area of representing 3D data in a computer, the mapping community's needs are well-met by an international standard: ISO 19107:2003 Geographic information – Spatial schema.

The State of the Art:
At present there is no software that can perform the complicated geometrical computations that are needed to build ISO 19107-compliant topology and geometry .

Current Geographical Information Systems (GIS) use 2D or 3D coordinates but build 2D topology by projecting (and forcing) spatially complex relationships to a simple plane. Stereo photogrammetrically-derived feature data or digital elevation data can represent only the outside of urban terrain objects. A picture of the outside, alone, is not sufficient. Representations of exterior surfaces, alone, are not sufficient to perform 3D analysis or to verify that geospatial relationships are correct.

Outside of the mapping community, commercial databases do not support either 3D geometry or 3D topology, which complies with ISO 19107. Commercial database software supports 2-dimensional topology only, and not full 3D geometry. Commercial database software does not does not provide for the storage of ISO 19107 data structures, or for the display and query of 3D topology and geometry. There is no commercial 3D topology builder.

The New Idea:
The government seeks software to build, validate, edit, query, and display ISO 19107 3D topology and 3D geometry. This software must perform 3D geometric operations, such as intersection and buffering, which are necessary to build ISO19107 3D topology and geometry.

This software will build topology on a variety of input sources, such as CAD files or GIS files which have (X,Y,Z) coordinates. The software will rebuild topology on ISO 19107 objects which have been edited after they were initially input into a database. The software will rebuild topology when new data, such as a chemical weapon cloud, has been added. The software will automatically alter the geometry of data to within a “snap tolerance”, so that topologically-correct data can be built. The software will automatically verify that 3D topology and geometry are correct.

The contractor will provide query and display software, so that users can query ISO19107 objects, their boundaries, and co boundaries, to verify that topology has been successfully created.

Impact:
An ISO 19107 topology builder will greatly ease the burden of importing and digitizing terrain features into ISO 19107 data structures and will provide the unique capability to automatically detect geometric and topological errors as it performs the validation process. It will also enable users to add new data such as a weapon range, a no-fly zone, a cellular communication range, or a chemical weapon cloud and rebuild topology by intersecting the new data with the old. This updating of topology is a necessary step before 3D analysis is performed. Software such as buffering will improve our ability to perform 3D analysis.

An ISO19107 3D topology builder will be an important tool for Mission Planning in complex and urban terrain or for Homeland Security. The DOD, Army, Department of Homeland Security and Future Combat System need this software to perform vital 3D analysis in an urban operation.

PHASE I: Complete a research plan and demonstrate some basic functionality of the proposed solution. The research plan will include a plan for the design and development of a 3D topology builder, the ISO 19107 data structures, query and display software.

PHASE II: Follow the research plan of Phase I to develop the 3D topology builder together with the attendant query and display software. The contractor will demonstrate the ability to build ISO 19107 3D topology and geometry on input data, from a variety of sources. The contractor will demonstrate the ability to add new data and to rebuild topology. The contractor will demonstrate the ability to verify that topology is correct and to correct minor errors by snapping.

PHASE III DUAL USE APPLICATIONS: This SBIR would result in a technology with broad applications in the civil and Homeland Security communities by providing a new, unique commercial capability to build and verify 3-dimensional geospatial topology and geometry. This software will be important to emergency response and to fire and rescue operations – for example, to plan routes of entry and exit from burning buildings. This software could be used by the medical research community to build topology on 3D protein models. Utility and mining industries could this software to map toxic gas in underground passages.

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KEYWORDS: Three-dimensional, 3D, Topology, ISO 19107, Urban Battlespace, GIS

A06-137 TITLE: Enabling Cross-Domain Exploitation of a Common Geospatial Database

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: The objective is to realize a means to enable a single geospatial database to support diverse applications. More specifically, it is to design and develop a way for a common geospatial database to support multiple military application domains, including C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance), modeling and simulation (M&S), battle command, mission planning and rehearsal, and embedded training. The U.S. military should be able to generate 3-D visual simulations automatically from a single, common geospatial database - the same database that supports less visually demanding but more analytically demanding applications such as Semi-Automated Forces (SAF). Ideally, both SAF applications and urban combat mission planning applications would be able to directly exploit the same geospatial database.

DESCRIPTION: This research and development effort will bridge domains to complete the linkage between geographic information systems (GIS) and associated geospatial databases, and 2-D/3-D visualization and simulation capabilities. Applications that require geospatial data tend to use the same basic information. However, the prevailing situation is one in which the same original geospatial data must be manipulated and transformed in various ways to support multiple military application domains. For example, military mission planners have traditionally relied on image generation systems that use unique, proprietary run-time databases. It can be argued that such run-time databases are just vestiges of historical limitations on processor speeds. As these limitations are rapidly diminishing, run-time databases ought to become unnecessary and obsolete. It should be possible to generate visualizations and simulations on the fly from a single, common geospatial database – not from multiple run-time databases that are costly to regenerate. This common geospatial database should support visualization and analysis for both humans and machines, so there can be direct use by both the visual simulation and SAF communities.

To achieve this goal, tools must be created that will allow the seamless and lossless ingestion of data from a common geospatial database by domain-specific applications. These tools must be aware of application-specific data requirements. They must be able to serve data from the common database, making all necessary conversions. This will entail data formats, data models, data types, data encoding, etc. Appropriate metadata will need to be generated to identify changes that have been made. Data resulting from domain-specific analysis must be available to users in other domains. Hence, the tools must also provide a reverse process for the seamless and lossless posting of data from the domain-specific applications to the common database.

In the past, the great diversity in both the types of geospatial data and the way they are used has prompted some simply to focus on the creation of and mandating of standards. This topic calls for a more global approach. This effort will require an examination of the fundamental structure of geospatial data, and a breakdown of the processes of using geospatial data. It will require the creation of a framework for data models that can represent any geospatial data, and enable efficient use and reuse of such data.

The entire range of relevant military applications - from generating detailed, large-scale 3-D urban scenes to supporting small-scale (large-area) multi-player simulations – will benefit from the achievement of the goals of this topic.

PHASE I: Design and describe in detail a method by which a single, common geospatial database can support multiple military application domains, including C4ISR, M&S, SAF, battle command, mission planning and rehearsal, and embedded training.

PHASE II: Develop a system based on the method described in Phase I by which a single, common geospatial database can support multiple military application domains, including C4ISR, M&S, SAF, battle command, mission planning and rehearsal, and embedded training. Demonstrate the system to show that a single, common geospatial database can support visualization and analysis for both humans and machines, and there can be direct use by both the visual simulation and SAF communities.

PHASE III: The desired capability will support a broad range of military and civilian applications – in fact, any applications that depend on geospatial data, especially those that require rapid updates. Civil applications include traditional disaster relief, emergency response, police/security force asset management, environmental studies, urban planning, site surveys, vulnerability assessment, crime scene investigations, real estate, tourism, television news, and more.

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KEYWORDS: common geospatial database, geospatial data, cross-domain, multiple applications, data modeling, metadata, formats, exploitation

A06-138 TITLE: Nanotechnology for Neutralization of Biowarfare Agents in Buildings

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective is to develop and demonstrate emerging technology to both neutralize and verify neutralization of biowarfare agents in buildings.

DESCRIPTION: Currently there is no real-time technology to both neutralize airborne biological warfare agents within buildings, and determine when the 100 % neutralization end-point has been achieved. Conventional neutralization validation technologies rely on collection of wipe samples to determine if any existing colony forming units are viable. If the samples can be induced to multiply, they are live, and complete neutralization has not been achieved. Therefore, there is a need to develop and demonstrate new technology to accomplish rapid effective neutralization and to identify when the clean up is complete and what fraction of the biowarfare agent pathogens have been killed. Furthermore, the non-availability of buildings during decontamination is costly and can severely impact the execution of critical missions.

PHASE I: Develop nanotechnology incorporated in coatings on wall or ceilings of buildings to neutralize and identify “live” vs. “killed” spores, bacteria, and viruses using simulants for the biowarfare agents, such as anthrax, in a laboratory setting. Neutralizing biocide could be released from nanovesicles, such as liposomes or nanocapsules when triggered by the presence of live biowarfare agents. The technology should be able to distinguish between live pathogens and those killed by biocides, such as chlorine dioxide. 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, such as Bacillus Globigii for Anthrax, and (2) MS-2 virus for smallpox, (3) Erwinia herbicola for plague, and (4) Ovalbumin simulant for bacterial toxins. Candidate technologies include, but are not limited to nanocapsules and dendrimers that contain biocideto be released upon demand. The technology should have the potential to be able to display in real time the number and identity of "live" pathogens versus the number of "killed" pathogens at a positive detection rate of 95%, and a false positive rate of less than 5%.

PHASE II: Demonstrate biowarfare agent neutralization technology on building surfaces, such as walls and floors, and determine the sensitivity of detection, particularly when there are less than 5 colony forming units (cfu) of simulant of biowarfare agent per square centimeter.

PHASE III: This technology has dual use application in Post Office Buildings and other government and commercial buildings which could be impacted by a terrorist act. Future biowarfare agent release could happen in civilian buildings such as mailrooms, where packages are received and handled. Furthermore, additional commercial applications include the use of these technologies for triggered biocidal release on walls and floors of builgings where a high degree of cleanliness must be maintained, such as hospitals, restaurants, food processing facilities, and washrooms and shower stalls.

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KEYWORDS: biological warfare agent, internal release, external release, killed spores, live spores

A06-139 TITLE: Hydrogen Reformation of Renewable Ethanol for Military Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Battlespace

OBJECTIVE: Design and build a prototype reformer to demonstrate efficient hydrogen production from renewable ethanol (E85) fuel which can be used for fuel cells, hydrogen vehicles, and other military applications.

DESCRIPTION: Ethanol is a domestic, viable, abundant, and truly renewable liquid fuel with an established production, transportation, and storage infrastructure. When integrated with fuel cell technology it enables the distributed generation of electricity and hydrogen. Ethanol fueled distributed generation could enhance energy security, reduce air pollution, expedite the introduction of a "hydrogen infrastructure, " lessen dependence on foreign oil, and eliminate further strain on limited domestic natural gas supplies for power production. The 2005 Army Energy Campaign Plan also cites the goal of increased use of renewable energy and expansion of use of alternative fuels at Army installations.

The technology for reforming 100% or "neat" ethanol into hydrogen is well established and poses no significant challenges. However, only denatured ethanol products such as E95 (95% ethanol, 5% gasoline) and E85 (85% ethanol, 15% gasoline) are made available for distribution on a wholesale level. Sulfur (heavy mercaptans) and corrosion inhibitors in these fuels decreases the activity levels and the lifetime of the catalysts used for hydrogen reformation. Today's state of the art catalysts can reform E95 fuel with a sulfur content (heavy mercaptans) as high as 10 parts per million (ppm). The effective lifetime of these state of the art catalysts is up to 25,000 hours with an acceptable activity level degradation of 10% - 20% over this effective lifetime. Since E85 fuel will be more readily available at an Army or DoD installation, the stretch goals for catalysts for hydrogen reformation of ethanol should be based on the parameters for E85. These catalysts would be required to reform E85 fuel with up to 20 ppm sulfur (heavy mercaptans), while achieving an acceptable degradation of 10% - 20% over an effective lifetime of 40,000 hours. It should be assumed that corrosion inhibitors such as Octel DCI-11 (20 pounds per thousand barrels of ethanol [PTBE]), Petrolite Tolad 3222 (20 PTBE), or Nalco 5403 (30 PTBE) will be present in the E85 fuel, and their effect on catalyst performance should be taken into account.

PHASE I: Determine the technical feasibility and requirements of producing catalysts which can reform E85 fuel based on the performance parameters in the Description. Determine procedures for laboratory synthesis of candidate catalysts for reforming E85 fuel which can meet the requirements in the Description.

PHASE II: Synthesize candidate catalysts for ethanol reformation as per the Phase I results. Develop, produce, and demonstrate laboratory operation of a prototype E85 fuel reformer capable of achieving 40,000 hours of operation with acceptable (10% - 20%) degradation levels over this lifetime. Design laboratory experiments and models such that limited experimental results can substantially validate the expected effective lifetime of 40,000 hours.

PHASE III DUAL USE APPLICATIONS: This reformer could have widespread civilian applications where backup power or clean, efficient distributed power is required with on site storage of fuel; or where on site hydrogen production is desired for refueling hydrogen vehicles or for other hydrogen applications.

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KEYWORDS: hydrogen, reformation, fuel cells, ethanol, E85, renewable, biomass

A06-140 TITLE: <u>Intelligent Tactical Electric Grid Control</u>

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: Design and build an inexpensive portable "intelligent" electrical control system that can be installed into tactical power grids to provide appropriate load shedding and demand management for increased grid reliability.

DESCRIPTION: Small-scale electrical grids, such as those used for tactical or base camps must be sized to meet anticipated peak loads. This sizing constraint results in electrical generation systems that are rarely operated at the rated capacity. For Army applications, the average electrical demand has a part load ratio (i.e., the ratio of actual power required to the rated capacity of the generators) of 10% to 15%. Operating generators at these low part load ratios results in poor fuel economy (twice the amount of fuel required per kilowatt-hour [kWh] of electricity generated), wet stacking (engine fouling), high maintenance requirements, and subsequently a high overall cost.

So, why not match 'average' power demand with generator sets so that part load ratios of 80+% are realized and thus avoid the above-noted operating issues associated with low part load rations? The problem is that there is no current ability to shed 'peak' load demands in a prioritized manner for those few occasions when net power demands would exceed the 'average' power demands.

This problem could be mitigated if power distribution systems had the ability to perform intelligent load shedding near the physical point of demand. Intelligent load shedding could temporarily cut off the flow of electricity to loads according to a prioritization scheme that insured that the most important loads remained on at all times and that the least important loads would be shed first. This strategy implies the need for hardware that could open or close circuits close to the point of demand, since high and low priority loads are often located near to each other. There would also be a requirement for getting the control signal to the hardware and a control algorithm that centrally aggregates demand, and dispatches signals to maximize overall grid performance. Funding permitting, an added feature for this concept would be to autonomously start reserve auxiliary power units (APU) in combination with autonomously shedding non-priority loads. The immediate load shedding would address critical power needs where even a second of power interruption would be destabilizing. The starting of reserve APUs would facilitate the automatic resumption of power demands that were shed to assure uninterrupted operation of the most critical demands.

PHASE I: Study load profiles found in Army tactical applications. Develop overall system design based on representative load profiles. Develop the network architecture and control strategies, and weigh risks and tradeoffs of proposed solutions compared to other design choices.

PHASE II: Develop, demonstrate, and validate a scaleable prototype system in a realistic environment. Demonstrate that loads can be “intelligently” dispatched so that a threshold is not exceeded, and that maximum efficiency of generating sources is obtained.

PHASE III: This system could be used in a broad range of civilian applications where reliable backup power is required.

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KEYWORDS: distributed power, energy, network, reliability, tactical grid

A06-141 TITLE: Monitoring Tire-Soil Interaction

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To mature and transfer a system to detect internal heat and pressure changes within the inside of a tire by use of sound. The system consists of a piezoelectric film mounted to the rim of a tire. Using this passive system, vibrations inside the cavity of the tire are used to monitor pressure and temperature changes. The research is expected to provide the Army a method of monitoring tire-soil interaction which will ultimately advance mobility on the battlefield. The proposed effort is of particular importance because the Future Combat System (FCS) will operate at high speed under extreme off–road conditions. The current direction of the FCS mandates that the Army must provide proactive R&D work focused on how to evaluate wheel designs for advanced FCS vehicles.

DESCRIPTION: Many factors besides the thermal buildup contribute to these changes: vehicle speed; deflection of sidewalls to accommodate the weight of the vehicle and the tractive force between the wheel and the ground and time in operation. In some cases the ability to detect an eminent failure could result in the saving of human life or prevent destruction of equipment. In other cases, monitoring these pressures or temperature changes may reveal important information about the mobility or design of a vehicle. Temperature and pressure changes are especially important in the case of airplane tires and truck tires, which travel at high speeds, carry heavy loads, and are subjected to higher pressures than normal automotive tires. The proposed research considers inexpensive methods to evaluate changes in the tire through, insonification, thermal changes, and pressure, measured inside the tire. The research also considers an existing federal patent. This patent introduced a piezo-electric film for monitoring changes in tire-terrain interaction. The use of piezo-resistive materials, lasers, thermal digital cameras, potentiometers, and octahedral stress transducers are to be considered for definition of the performance of the tire. Resulting products include inexpensive sensors to provide measurements of the tire when operating on a ridged and deformable surface. Initial analytical methods include Fourier analysis, wavelets, and Kalman (state space) filters to identify the most appropriate method to calibrate each system with the frequency range emitted internally by the tire. Theory suggests as the tire heats up, changes in the phase of sound transmitted internal to the tire occur. This research envisions use of insonification to analyze tire performance and possibly pinpoint localized failure.

PHASE I: In Phase I is the investigation of algorithms to identify correlations between internal disturbances within the tire during normal operation as related to thermal buildup and pressure changes. The tire should be subjected to typical operating pressures, for example 0 to 60 psi and temperatures from 20 F to 160 F. Waves generated synthetically or through operation of the tire during these pressure and temperature changes will be measured. Research should consider optimal frequency and amplitude for passive and active monitoring of changes in the temperature and pressure during normal tire operation. In Phase I, a tire with a piezoelectric band mounted to the rim and/or other passive measurement system should be tested on a tire drum. Using a slip ring or other transmission device, sensors for the piezoelectric matériel, thermocouples, and pressure transducers tire data will be recorded remotely. The pressure transducers and thermocouples will measure a minimum of two locations internal to the tire cavity. The tire will be monitored externally with a thermal camera. The tire will be run until a safe operating temperature is achieved, and data will be collected to define correlations between pressure, temperature, tire deflection, tire type, and phase changes in the sound recording system. Two or more tire types will be monitored during this testing to determine if variations in the manufacturing of a tire produce different sound patterns.

PHASE II: During Phase II the research organization will mount the tire to a vehicle. The vehicle will be operated on roads with the same recording information used in Phase I. Methods of filtering variations in sounds introduced by operations outside the lab will be considered. Correlations will be considered between temperature, pressure, operating speeds, and phase changes monitored on the piezoelectric matériel. The research will introduce external flaws to the tire such as local failures to determine if these localized changes can be observed. The tire will be tested on different concrete and asphalt roads. The vehicle will be tested in at least one off-road area to determine if changes in tire/soil interaction can be observed.

PHASE III: This system of tire performance monitoring will be used by commercial vehicle designers to test on- and off-road stability of proposed chaises and body configurations and by tire manufacturers to determine the stability of new tire designs and the rate of wear of different types of tires, especially those composed of recycled materials. Trucking firms, taxicab companies and other firms that manage large vehicle fleets will find the system attractive in order to make the best use of tires, extend tire life, and make operations more economical. The system may be especially attractive in competitive auto racing where significant advantages are gained through optimum tire performance.

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8) Luchini, J. R., Motil, M. M., and Mars, W. V., “Tread Depth Effects on Tire Rolling Resistance,” Tire Science and Technology, TSTCA, Vol. 29, No. 3, July-September 2001, pp. 134-154.
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10.) Kagmi, K and Fujikawa, T., “Measurement of Tire Temperature Distribution during Travel,” 2000, Society of Rubber Industry Japan, Vol. 73, no. 8, pp. 430-434.

11) Park, H., Youn, S., and Kim, N., Analysis of Temperature Distribution in a Rolling Tire Due to Strain Energy Dissipation, 1997, Tire Science & Technology, vol. 25., no. 3, pp. 214.

KEYWORDS: Internal Tire pressure, tire/soil interaction, sound propagation

A06-142 TITLE: Detection of Vehicle Type and Buried IED's Through Remote Sensing

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: In this research the Army seeks to utilize spectroscopy or other means to identify and discriminate disturbed soil surface and correlate this data with physical changes in the soil. A strong correlation between the thermal emissions, physical changes of the soil, and the method used to disturb the soil may support identification of improvised explosive devises (IED's) and descrimination of vehicles. The overall objective is to use emissions from the soil to time stamp and identify the nature of a distrubance as related to IED's and vehicle traffic.

DESCRIPTION: When the ground surface is disturbed, soil and vegetation is altered by a load imposed and the method. After distrubance, the soil recosolidates with time, providing a timestamp of when the changes occurred. Initial emissions from the soil are altered based on the localized redistrubutions in density, quartz content, texture and moisture of the soil, each property ideally related to the method used to disturb the soil. A remote sensing strategy that discriminates changes in spectral observations of these disturbances would provide information of great benefit to operational planners. The thermal long-wave infrared band (LWIR) (8 to 14 microns) is suited for analyzing terrain since the LWIR signature of soil is highly sensitive to changes in soil properties and conditions. Soil compaction, fragmentation, and pulverization are the primary phenomena that determine the thermal signatures of ruts (tracks) left behind a vehicle. These phenomena can have opposing effects on soil signature. In the LWIR, emissivity tends to increase with decreasing soil particle size (such as would be produced by soil fragmentation and pulverization) while emissivity decreases with compaction. I n many soil types, steel tracks with cleats will fragment and pulverize soil, while rubber-tired vehicles tend to be less disruptive of the terrain and hence compact soil--causing different LWIR images. Tests conducted by the U.S. Army Engineer Research and Development Center proved that thermal infrared observations of vehicle tracks could discriminate between some types of vehicles, but some soil types often masked the difference. The proposed research seeks to differentiate between types of soils distrubed by vehicles, differentiate the effects of vegetation, and seek to determine the emplacement of IED's.

PHASE I: Research in Phase I is directed toward the creation of models wherein vehicle tracks in the thermal LWIR band may be observed. The model will include varying thermal emissions between the various loading patterns of the vehicles and the track or wheel pattern. Correlations between the thermal emissions and at least on soil type will be defined. This data will be compared against measured data (such as in Eastes, Mason, and Kusinger, 2004). Soils data defined within the model will include typical measured properties (such as density, moisture, and texture) and correlations to expected changes in these properties related to thermal emissions. Discrimination between IED and buried mines will be depicted in the model in a similar manner.

PHASE II: Phase II will extend the research to multiple soils, IED, and vehicle types. Investigation of factors affecting track signatures, including soil type, vehicle/surface contact area, and alteration of surface porosity/density will be undertaken. A system to model and simulate vehicle tracks measuring changes in the emission properties of the soil as a vehicle passes over terrain will be created that produces a thermal infrared image of the terrain as would be seen by a remote sensor. Through a series of field tests, a database of vehicle, soil type and condition, and thermal/infrared measurement of soil and vehicle track properties (emissivity, temperature, etc) will be created. The extended modeling system to analyze data extracted from remote sensing and compute the probability that the observed vehicle tracks were created by the vehicles listed in the database – thus proving the ability of system to identify tracks left by an unknown vehicle. Extend modeling system to predict time of day (given weather forecast, soil type) and other sensing conditions that would yield the best thermal infrared data by which to discriminate vehicles based on observations of their track. Investigate 3D modeling of soil conduction to assess if this level of thermal modeling combined with a soil disruption model would produce more accurate predictions of vehicle tracks as observed in the thermal infrared. Define and length of time buried IED's exist based on observed thermal emissions.

PHASE III: Signature analysis of thermal vehicle tracks can provide military planners and battlefield analysts with information about enemy vehicle strength or threat capability even when the vehicles are out of sight (hidden/camouflaged, departed out of the observation area) and/or when the enemy deploys spectrally/visually identical decoys. The simulation code could also be used to train soldiers and analysts in interpreting remote sensor images. The terrain and terrain-interaction models produced by this effort can be applied to highway/rail temperature prediction, architectural modeling, and hydrology.

REFERENCES:

1) Eastes, J. W., Mason, G. L., and Kusinger, A. E., "Thermal Signature Characteristics of Vehicle/Terrain Interaction Disturbances: Implications for Battlefield Vehicle Classification", Applied Spectroscopy, Vol. 58, No. 5, pp. 510-515, May 2004.

KEYWORDS: Remote sensing, vehicle discrimination, vehicle tracks, vehicle-terrain interactions, thermal signature, infrared

A06-143 TITLE: Degradation Modeling of Composite Materials Used in Military Construction

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this research is to develop and demonstrate molecular scale models of fiber-matrix interactions and macroscale models for predicting the degradation mechanisms of diverse composite materials used in military facilities.

DESCRIPTION: Composite materials are being increasingly used in improving the rehabilitation and durability of the Army building systems, seismic upgrading and repair, and improved building designs. For example, composite materials are used in wet-layup form as appliqués and wraps for these purposes. However, in some cases, these composite materials have not exhibited satisfactory long-term performance in the field. There are heightened concerns related to the overall performance of these materials under harsh and changing environmental conditions. Currently, no capability exists for reliably projecting the behavior of composites used in emerging Army facilities in various environments. A means of predicting degradation mechanisms of composite materials and macromodels is needed.

PHASE I: Determine the feasibility of using molecular scale models for predicting the degradation mechanisms of various emerging fiber-reinforced composite materials in wet-layup form for strengthening building construction and other structural applications. The models should include the simulation of field exposure to the synergistic degradation effects of the weather, including ultraviolet radiation from sunlight, under a variety of situations that include various loading conditions and extreme atmospheric environments, viz., hot/dry, hot/wet, cold/dry and cold/wet.

PHASE II: Develop and demonstrate macromodels of composite materials degradation mechanisms including: (1) glass transition temperature depression, (2) cure progression threshold, (3) relaxation and creep threshold, (4) chemical degradation of the matrix, (5) crack growth in fibers and (6) fiber/matrix failure. Demonstrate the use of macromodels to predict the behavior of various composite materials in seismic upgrading and repair, and improved building designs, based on an understanding of molecular scale interactions between fiber and matrix.

PHASE III: The technology to be developed under this research can be expected to provide better designs of military and civilian building and structures. Candidate customers are designers of buildings on military installations as well as the occupants of the buildings, especially military facilities that must remain structurally in tact during seismic or blast events in order to ensure the continuity of the mission.

REFERENCES:

1) N. L. Post, J. V. Bausano, J. J. Lesko, S. W. Case, J. C. Duke, The Role of Durability In Reliability-Based Design of Composite Materials For Civil Structures, Proceedings of the Second International Conference on Advanced Polymer Composites for Structural Applications in Construction-ACIC 2004, L. C. Hollaway, M. K. Chryssanthopoulos, and S. S. J. Moy, 593-601, 2004.

2) N. Post, J. Bausano, S. W. Case, and J. J. Lesko, Reliability & Durability Based Analysis for the Design of Composite Structural Service Life, ACMBS-IV Conference, July, 2004.

KEYWORDS: composites, degradation, modeling, fiber-matrix interaction

A06-144 TITLE: “Smart” Intermodal Shipping Containers

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: To develop the next generation of ISO “Smart” intermodal shipping containers that will capable of being tracked, traced, inventory capable, and chemical/biological attack hardened to meet the Department of Defense critical logistical requirements for providing In-Transit Visibility in operational theaters.

DESCRIPTION: The current ISO intermodal shipping container is a basic steel “dumb” box whose traditional labor-intensive manufacturing fabrication method has been outsourced to foreign countries for the purpose of obtaining lower prices. New advanced manufacturing processes with polymer molding, material co-mingling and dynamic structural design will allow the manufacturing process to shift from a labor intensive single unit to mass production capability with almost a 50 % reduction in overall weight, no loss in structural integrity and resultant lower unit cost. Hybrid polymer containers may also be incorporated with e-textile materials that could detect unauthorized entry and chemical agent, biological agents, explosives, and illegal drug and allow for future fiber optic sensing systems. Polymer containers will allow domestic sources for procurement and eliminate the need to purchase/lease outside the U.S. The current containers have not been hardened or integrated for the chemical/biological attack survivability. The contents of the current containers would likely be contaminated in an attack situation.

The next generation of ISO “Smart” intermodal shipping containers must be chemical and biological defense hardened, and RFID (Radio Frequency Identification Device) capable enabling the DoD to reach established goals and objectives through enhanced CB protection, total asset visibility, improved life cycle, accurate financial audits of inventory, and logistical tracking of container movements. RFID (active) interrogation within an enclosed steel container is impossible because of radio wave propagation against steel walls. Polymer walls, being less dense while maintaining structural integrity, will allow penetration of the RF signal without false readings. Disposable low-cost RFID passive tags can be applied at the most efficient and economical level (individual item, case, pallet, etc) to meet minimum tagging requirements for data acquisition. GPS transponder will provide real time tracking capability. From a commercial standpoint, x-rays will easily pass though polymer walls, increasing homeland security. This new container system will also allow for a single source logistical system capable of wireless encrypted data transmission to future handheld and fixed data download stations and centralized data retrieval.

Commercial applications for this technology are extensive and include commercial merchant shipping, dry and refrigerated cargos (using a foamed polymer shell), FEMA emergency housing, large volume potable water containers, meeting Department of Homeland Security directives regarding container security and creating manufacturing jobs for U.S. taxpaying citizens.

PHASE I: The deliverable for the Phase I effort should include a feasibility study in addition to the design and development of a hybrid polymer ISO shipping container. The container must allow for a low cost manufacturing production system and full integration into DoD total asset visibility systems and chemical and biological hardening requirements. The design process, technical specifications, and identification of manufacturing materials should be completed to lead to Phase II.

PHASE II: Phase II will include the development of production prototype models capable of being tested to American Bureau of Shipping ISO standards; testing for CBRNE hardening; DoD deployment. At conclusion of Phase II, the delivery item should represent fully characterized prototype models to be used for operational evalutions in ongoing exercises in support of the DoD and/or homeland security.

PHASE III: Development of advanced manufacturing and engineering processes. The proposed "smart" container can be readily integrated into the civilian market for containers and mass distribution of goods to include retail and industrial markets.

REFERENCES:
1) "Use of Commercial Wireless Devices, Services, and Technologies within the Department of Defense (DoD) Global Information Grid (GIG)", April 14, 2004. DoDD 8100.2.
2) FIPS 140-2, 140-3, Security Requirements for Cryptographic Modules.

KEYWORDS: container, chemical agent, hardening, transportation, shipping containers, protection

A06-145 TITLE: Integrated Portable Explosives, Chemical Warfare Agent, and Radiation Detector

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

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 explore and develop a technology platform for detection of explosives, chemical agents, and radiation that is integrated/bundled, handheld, lightweight, GPS-compatible, that provides complementary, concurrent detection ability.

DESCRIPTION: Today's warfighters face multiple threats, especially in scenarios involving asymmetric warfare where traditional rules of conduct do not apply. Consequently, in seeking out weapons caches and covert threats, there is a need to locate and identify chemical, radiological, and explosives-based weapons. Mobile warfighters must still be able to operate, however, with minimal impediment imposed by carrying additional equipment or the need to change out equipment, especially when doing area sweeps. To date all existing sensing equipment for explosive, chemical, and radiological detection are single application, stand-alone systems designed for detection applications in their area of expertise.

Combining the capabilities of detection systems would result in the next generation of screening sensors to provide real-time detection and exact locations of contraband threats, giving the user the flexibility of sensing explosives, chemical agents, radiation, or all three simultaneously. This approach would minimize the amount of equipment that would have to be procured, deployed, and maintained in the field, therefore reducing the strain on logistics and tactical complexity.

The ideal device would weigh no more than five pounds, occupy a volume of no more than 850 cubic inches, operate on rechargeable batteries with a minimum operating time of four hours, and be capable of surviving in harsh field environments. The device must be able to detect explosives, gamma radiation above 50 keV, and a set of representative chemical agents to be defined prior to Phase II. A detection event of one type shall not render the system incapable of detecting the other threat materials and should permit recovery of detection capability of each type of analyte within five minutes. Operation of the equipment shall be possible for warfighters while wearing Explosives Ordnance Disposal (EOD) or chemical hazard/radiation protective clothing.

PHASE I: Develop a strategy and define a prototype for all-in-one sensing instrumentation with a proof-of-concept demonstration against explosive and radiological materials in addition to chemical warfare agent surrogates.

PHASE II: Further develop prototype equipment from the Phase I demonstration into a rugged, handheld lightweight, fieldable test unit for detection in real-world scenarios. Device must be able to simultaneously detect multiple threat materials in actual ambient environmental conditions.

PHASE III: The immediate multi-use markets will use the same or a similar tool to support homeland security, and in particular border and transportation security efforts. The successful sensor is likely to be capable of detecting chemical vapors and is thus suitable for numerous commercial and private sector applications to include industrial hygiene. Environmental and regulatory uses exist in the detection of chemical leaks, contaminants, and illegal storage of hazardous materials. Industrial users would be able to monitor chemical storage and processing systems.

REFERENCES:
1) Catalytic buffers enable positive-response inhibition-based sensing of nerve agents, Alan J. Russell, Markus Erbeldinger, Joseph J. DeFrank, Joel Kaar, Geraldine Drevon Biotechnology and Bioengineering Volume: 77, Issue: 3, Date: 5 February 2002, Pages: 352-357.
2) Fluorescent Porous Polymer Films as TNT Chemosensors: Electronic and Structural Effects, Y-S Yan and T.M Swager, J. Am.Chem.Soc. 1998, 120, 11864-11873.

KEYWORDS: Explosive detection, Mine detection, CW detection, IED, radiation, radiological, hazardous materials

A06-146 TITLE: <u>Association of Object Features and Attributes, with Limited</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Joint SIAP System Engineering Organization

OBJECTIVE: Develop techniques (and corresponding algorithms) that associate object features/attributes to the corresponding tracks in a decentralized, distributed data fusion environment.

DESCRIPTION: It is generally accepted that radar “skin tracking” of an aerospace object is inadequate to characterize that object; air battle demonstrations and evaluations have unequivocally shown that “skin track” is incapable of maintaining track continuity even in a moderately dense object environment. It is the intent of this proposal topic that this shortcoming be overcome by annealing non-kinematic features and attributes to each object’s track state. This challenge must be answered in a decentralized, distributed data fusion environment in which data from all sensors is shared among warfighting systems where it is fused.

Feature association has three facets: what signatures are available from an aerospace object; what sensors can sense those signatures; and what techniques and implementing algorithms exist to associate those signatures to the track state. The issue of combat identification adds one more challenge: if the association of features is correct, what conclusions can be drawn about the character of the object under observation?

The spectrum of features fall into two broad categories: those that require stimulation (e.g., Mark XII IFF, active radar sounding) and those that are received with no action on the part of the recipient (e.g., electromagnetic emissions from an object, reflected energy from a source apart from the recipient). In radio frequency media, sensing can occur in long wave (radio and radar), infrared frequencies, visual frequencies and very shortwave frequencies (e.g., UV through x-ray). In addition, for some, the energy can be acoustic (carried by air or water).

The class of signatures that gives positional resolution in addition to their defining signature is the easiest to associate with tracking representations. However, there are significant numbers of definitive signatures that do not lend themselves to position resolution. These are the ones providing the challenge of association.

PHASE I: Conduct research, simulations and analysis as needed to show feasibility of algorithms for improved object tracing and sensor fusion in a decentralized, distributed data fusion environment. Develop a demonstration/proof-of concept based on pertinent evaluation metrics in a Monte Carlo simulation.

PHASE II: Develop and evaluate a working prototype of the proposed algorithms for track state feature/attribute association. Build the algorithms in an appropriate language and identify performance evaluation metrics for evaluation in the IAMD Benchmark. The air defense scenarios in the IAMD Benchmark include targets with abrupt maneuvers, unresolved closely spaced objects and other conditions conducive to data mis-association.

PHASE III: Commercialization and transition transfer of developed products to the military and commercial markets. This includes conversion to compiled C++, or other languages appropriate for run-time improvements.

DUAL USE APPLICATIONS: This technology will be useful in any environment that requires object tracking such as air traffic control systems, ground tracking systems such as network security intrusion systems.

REFERENCES:
1) Y. Bar-Shalom, Track-to-Track Association for tracks with Features/Classifications, Department of Electrical and Computer Engineering, University of Connecticut, June 7, 2004.
2) Robert Popoli, Samuel S. Blackman, Design and Analysis of Modern Tracking Systems, Artech House Radar Library, Book News, Inc., Portland OR, 1999.
3) Proceedings of the annual SPIE Signal and Data Processing of Small Targets Conferences.

KEYWORDS: Feature aided tracking, multiple target tracking, sensor data fusion, and multiple sensor data processing

A06-147 TITLE: Association of Critical, Infrequent Data

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Joint SIAP System Engineering Organization

OBJECTIVE: Develop methods and pertinent algorithms that will allow infrequently arriving data to be to be effectively used in a decentralized, distributed data fusion environment. A subordinate problem is to develop effective methods for forming frames of data for effective data association with data from multiple sensors that are not synchronized.

DESCRIPTION: There are a number of circumstances in which infrequent data must be associated with a track state to resolve track and combat identification (CID) ambiguities. Examples:

· Some intelligence data that is collected on an object may not be immediately available but is critical for characterizing the object. While track data association is typically accomplished on recent data, the requirement to associate the very late data with current track state is challenging and beyond the current state of the art.
· One of two or more objects provides identification friend or foe (IFF) but they are too close to identify which is emitting the IFF message. Sometime later one of these objects is now close to another object and again provides valuable IFF. This new information is critical to identify which of the original objects provided the IFF and which did not. However, current multi-hypothesis/multi-frame association (MHT/MFA) trackers are not designed to take advantage of this type of data if the times between IFF (or other feature) data are too infrequent.
· A sensor provides two dimensional (2D) data on targets but provides it intermittently/infrequently. The association with other radar tracking data is challenging and may well degrade tracking and object characterization should the data be incorrectly assigned. MHT/MFA trackers can potentially reduce the probability of miss-association; however, current versions of such trackers cannot take advantage of infrequent 2D data if the separation times are too great.

A common thread among the examples is a requirement to maintain ambiguous data tagged to “objects of interest” so that subsequent, infrequent data can be used to resolve the ambiguity. It appears that any solution to the association of infrequent data will depend heavily on the manner in which track states (including all germane features) are maintained for reference. A related problem is organizing measurements appropriately into frames of data.

This challenge must be answered in decentralized, distributed data fusion environment in which data is shared among warfighting systems where it is fused to form track states.

PHASE I: Conduct research, simulations, and analysis to show the feasibility of algorithms for late/sparse data association from decentralized, distributed sensors. Develop a demonstration/proof of concept using a Monte Carlo simulation.

PHASE II: Develop and evaluate a working prototype of the proposed algorithms. Build the algorithms in an appropriate language and identify performance evaluation metrics. Evaluation will be conducted using the Integrated Air and Missile Defense (IAMD) Benchmark, a fine grained Monte Carlo simulation developed by the Joint Single Integrated Air Picture System Engineering Organization (JSSEO). The scenarios in the IAMD Benchmark include objects with abrupt maneuvers, unresolved, closely spaced objects, and other conditions conducive to data mis-association.

PHASE III: Commercialization and transition/transfer of developed products to the military and commercial markets. This includes conversion to the ANSI standard C++ programming language that is appropriate integration into warfighting systems.

DUAL USE APPLICATIONS: The capabilities provided by this technology development include application to air traffic control, ground tracking for intrusion detection (homeland security) and other related applications.

REFERENCES:
1) R. D. Hilton, D. A. Martin and W. D. Blair, Tracking with Time Delayed Data in Multi sensor Systems, document number NSWCDD/TR-9e/351, Naval Surface Warfare Center, Dahlgren, VA, August 1993
2) Y. Bar-Shalom, Out of Sequence Measurement in Tracking: Exact Solutions, University of Connecticut, 7 June 2004.

KEYWORDS: Multiple target tracking, sensor data fusion, algorithms, multiple sensor data processing

A06-148 TITLE: <u>Network Service Availability and Debug Technology</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Develop an innovative methodology and technology for management and verification of the availability of services while traversing a global network or an autonomously controlled Internet Service Provider (ISP).

DESCRIPTION: Many Department of Defense (DOD) services use global networks (such as the Global Information Grid (GIG)) to communicate information between enclaves that are not physically co-located. Typically, they are only clients of the larger global network leveraging the wide area network to support information exchange, or service requests between various computer applications. Unfortunately, many service providers, such as GIG, restrict applications that utilize their networks by various means to include using access control devices. Because of this approach, these restrictions can prevent the completion of some necessary information exchanges or service requests, and they do not provide feedback to the corresponding applications of the network.

For example, an application running a service at Fort Bragg, NC may need to transmit data using a proprietary protocol to another application located on a computer system at Fort Drum, NY via the Non-Classified Internet Protocol Router Network (NIPRNET). Thus NIPRNET functions as an Internet Service Provider (ISP) between these sites. Security policy and network management enforcement points within an ISP may block or impede certain types of protocol communications such as service announcements, hand shake protocols, and multicasts that can interfere with end-site application function.

When the applications cannot fully exchange information due to NIPRNET imposed restrictions, problems can occur and there is often very limited information available to the system/network administrator at Ft Bragg or Fort Drum to troubleshoot the cause. For network administrators debugging such network induced application failures, they often only know that both applications appear to be working properly at end-site locations but fail to properly connect or communicate over the NIPRNET due to an unknown reason. This is because neither end-site location has the ability or privileges to investigate the NIPRNET backbone configurations.

Research and development is required to develop a capability to assist network managers who utilize the GIG, ISPs, or other autonomously controlled wide area networks but cannot determine which services are available between end-sites. This capability must support detecting and identifying where services are breaking down in the communication path between locations. The capability must support determining why applications fail within the network by analyzing available application and protocol information, and to determine if the problem is local, at the service provider, or in the communication path between the end-sites. The result of this analysis will enable adjusting the service level agreements, to include QoS policies between the application user and the service or network provider. The architecture defined for this capability must be based on current and emerging commercial standards and should be built on a non-proprietary architecture.

Any research and development that promotes mobility to the warfighter would be beneficial to Joint Network Transport Capability Spiral (JNTC-S).

PHASE I: Perform a paper study documenting the preliminary concept and theory of operations for a novel solution to detail availability of services and to identify the reason/location of service disruption. Identify a proof-of-concept prototype set-up for Phase II. Develop a test plan for Phase II along with performance criteria to evaluate the solution and ensure the solution identifies problems in communications when they occur in global networks.

PHASE II: Complete design and development of a prototype implementing the solution recommended in Phase I. Demonstrate the prototype for the availability of services and identity reason/location of service disruptions. The solution should be demonstrated within the representative architecture where multiple clients systems are attempting to communicate using priority applications across a network not control by the clients (i.e., an external ISP). The demonstration should use the proposed test plan and performance criteria outlined in Phase I to ensure that the solution accurately identifies disruption of service within the network when they occur.

PHASE III: During this phase, the Phase II 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 documented software (both executable and full 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. 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) N. Freed, "Behavior of and Requirements for Internet Firewalls," Internet Engineering Task Force, June 2000.
2) T. Martin and B. Hickman, "Benchmarking Methodology for Firewalls," Internet Engineering Task Force, July 2000.
3) J. Kuthan and J. Rosenberg, "Firewall Control Protocol Framework and Requirements," Internet Engineering Task Force, June 2000.
4) E. Lear, "ICMP Blocked Notification," Internet Engineering Task Force, August 2000.
5) J. Rosenberg, D. Drew and H. Schulzrinne, "Getting SIP through Firewalls and NATs," Internet Engineering Task Force, February 2000.
6) G. Winfield Treese and Alec Wolman, "X through the firewall, and other application relays," in Proceedings of Usenix Summer Conference, (Cincinnati, Ohio), pp. 87--99, June 1993.

KEYWORDS: Network, services, protocols, Network Management, QoS

A06-149 TITLE: <u>Stateful Inspection Devices in an Asymmetric Routing Architecture</u>

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: Develop an innovative methodology and/or technology for integrating stateful inspection devices into asymmetric routing architectures.

DESCRIPTION: Currently, the Army tactical networks such as Joint Network Transport Capability-Spiral (JNTC-S) are integrating stateful inspection devices such as firewalls and intrusion detection systems (IDS) into their Tactical Command Posts (CP) to provide network security. These devices require monitoring communication of sessions in order to inspect to identify malicious user intent. Without monitoring all packets in a session, these devices can't follow session state and may fail in detecting malicious intent.

Army tactical networks are being built with "Plug and Play" capability to ensure ease of use to soldiers in the field. Also, these networks are built with redundancies in communication devices and network paths to ensure these CPs always have the ability to transmit and receive information even when operating in split or jump modes.

In Asymmetric routing architectures, session packets may take multiple paths in communication correspondence, and not cross these same stateful inspection devices. This occurs in these Army tactical CP networks when multiple communications devices are connected to the same network without a preferred data path defined. Normally, this problem is addressed using a preferred data network path. However, these tactical networks can't use a pre-planned network design without impacting network complexity. Preferred data network paths aren't flexible enough to adapt to the ever changing CP tactical networks (i.e. loss of communications, unit re-assignment, communications failover, and modularity). A solution is needed to overcome these architecture designs shortfalls and ensure that these stateful inspection devices can perform as designed to improve network security while still allowing required communications.

The proposed technology should be built on a non-proprietary architecture to provide an integrated solution.

Any research and development that promotes mobility to the warfighter would be beneficial to JNTC-S.

PHASE I: Perform a feasibility study documenting preliminary concept and theory of operations for a novel solution for integrating stateful inspection devices into asymmetric network routing architectures. All proposed solutions must have the ability to overlay onto existing CP tactical networks without impacting current architecture designs (i.e., architectural changes may impact other services in the network design). Identify a proof-of-concept prototype design that will be demonstrated in Phase II. The prototype design will include an asymmetric routing network integrating multiple stateful inspection devices demonstrating the novel solution. Develop a test plan for Phase II along with performance criteria to evaluate the solution and ensure the stateful inspection devices are capable of retaining session states.

PHASE II: Complete design, development, and demonstrate the prototype of the asymmetric routing solution from Phase I. The solution should be demonstrated within the representative architecture emulating the Army's Joint Network Transport Capability-Spiral (JNTC-S). The demonstration should use the test plan and performance criteria outlined in Phase I ensure that the solution is accurately ensuring state inspection devices are work as intended.

PHASE III: During this phase, the Phase II 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 documented software (both executable and full 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. 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) Jin-Ho Kim, Saewoong Bahk and Heejo Lee, “A connection management protocol for stateful inspection firewalls in multi-homed networks”, 2004 IEEE International Conference on Communications, Volume: 4, 20-24 June 2004.
2) Xin Li, Zheng-Zhou Ji and Ming-Zeng Hu, “Stateful Inspection firewall session table processing”, Information Technology: Coding and Computing, 2005. International Conference on ITCC 2005, Volume: 2, 4-6 April 2005.

KEYWORDS: Firewall, IDS, Asymmetric Routing, Stateful Inspection

A06-150 TITLE: Inspiratory Impedance as a Treatment for Traumatic Brain Injury

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: To develop a small, simple, lightweight noninvasive device designed to prevent or ameliorate neurological, physiological and histopathological brain damage by decreasing intracranial pressure (ICP) following traumatic brain injury (TBI).

DESCRIPTION: Research in the field of cardiopulmonary resuscitation has led to the recent development of an inspiratory impedance threshold device (ITD) designed to increase blood flow to the heart and brain. Breathing through an ITD creates a small vacuum within the chest relative to the rest of the body every time the chest wall recoils back to its resting position during the decompression phase (1). As such, ITD application can increase the vacuum within the thorax and double blood flow to the heart and brain. In recent experiments using a hemorrhagic shock model of apneic pigs, application of an ITD in conjunction with positive pressure breathing generated an immediate decrease in intracranial pressure (ICP) by about 7.5 mmHg (2). When the ITD was removed, ICP returned immediately to baseline levels. The impact of the ITD on ICP suggests a remarkable degree of concordance between changes in intrathoracic and intracranial pressures, which may have significant implications in the treatment of a number of disorders that alter brain function. These new findings also suggest that the vacuum created by the ITD causes a “waterfall” effect that increases blood flow by maximizing the pressure gradient across the cerebral circulation. Application of an ITD might therefore prove efficacious in clinical situations in which management of ICP is essential, such as traumatic (TBI).

Head and neck wounds account for 16–33% of all war-related injuries and are a leading cause of mortality upon evacuation to a definitive care setting (3, 4). In the civilian sector, firearm-related injuries are on the rise nationwide, with bullet wound injuries to the head being the most common cause of TBI–related fatality in the United States (5). Severe TBI portends a grim prognosis, with most victims dying within the acute post-injury period despite the advent of modern clinical management practices, including control of ICP (5). Therapeutic advances are desperately needed as the single most important determinant of outcome from TBI is the occurrence of secondary brain injury caused by increased ICP, which reduces cerebral perfusion pressure and results in cerebral ischemia (6). While a number of pharmacological or surgical approaches are being used, there is currently no proven non-invasive therapy for the treatment of elevated ICP (6). Because the ITD decreased ICP in pigs without TBI, it is possible that use of an ITD could produce a similar effect in TBI, thereby potentially reducing the occurrence or severity of negative neurological outcomes. Thus, proof of concept of ITD use in animal models of TBI (5) could suggest the future use of the ITD as an acute life-saving intervention as well as a treatment to decrease subsequent morbidity in both military and civilian settings.

PHASE I: This phase should result in a proof of concept workable device capable of decreasing ICP. In order to demonstrate and optimize the potential value of the ITD for the treatment of TBI on the battlefield, it will be necessary to 1) define the physiological mechanism(s) associated with the interaction between intrathoracic pressure and ICP, and 2) determine the best inspiratory resistance or cracking pressure for the ITD to work effectively and consistently in reducing ICP for a prolonged period of time. It will therefore be necessary to measure ICP in a sample of animals large enough to determine with statistical robustness if the ITD can consistently decrease ICP.

PHASE II: In this phase, experiments will be extended to an animal model of TBI. In addition to measurement of ICP, this model of TBI should be well-validated in terms of producing neurological, physiological and histopathological outcomes similar to those typically measured or observed in TSI patients. Proof-of-concept experiments will be performed that demonstrate that a decrease in ICP by ITD application will also ameliorate or eliminate detriments in brain tissue produced by TBI. Alternatively, the offeror may collaborate with investigators in the Department of Applied Neurobiology at the Walter Reed Army Institute of Research (WRAIR) in Silver Spring, Maryland who have developed such a model of TBI in rodents (5). For successful completion of this phase, the offeror must 1) modify the ITD for use in the anesthetized animal model; 2) be able to measure ICP in the animal model of choice; and, 3) perform a well-controlled study to determine whether ITD use decreases ICP in their well-established model of TBI.

PHASE III: This technology will have immediate battlefield application for use in TBI casualties. Furthermore, the ITD has the potential for civilian pre-hospital use by paramedics in the field or on ambulances for treatment of TBI. This may particularly apply to rural or other delayed extraction situations where deterioration of brain function by severely elevated ICP may be delayed.

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KEYWORDS: trauma, brain injury, intracranial pressure, impedance threshold device

A06-151 TITLE: Ultrasound or Ophthalmodynamometry Technologies for Battlefield Diagnosis of Traumatic Brain Injury

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Prototype and test a handheld or man portable system utilizing either ultrasound or Ophthalmodynamometry technologies that can provide battlefield triage of traumatic brain injuries (TBI). The system shall be able to provide diagnostic data related to intracranial pressure (ICP), and preferably cerebral perfusion pressure, blood oxidation and intracranial hemorrhage.

DESCRIPTION: Recent developments in ultrasound technology suggest it as one potential method for noninvasively monitoring intracranial pressure and cerbrovascular flow, while also detecting the presence of intracranial hemorrhage and decreased cerebral perfusion pressure [1-5]. Ophthalmodynamometry and Ultrasound-obtained optic nerve sheath diameter measurements have also been shown to provide accurate assessment of increased intracranial pressure [6-8]. To make these or any competing technologies practical for combat casualty care, they must be integrated into a portable, low-power diagnostic unit. Such a system should also have a simple interface that makes the system easy to use by medics, physicians assistants and general trauma surgeons in a battlefield setting. It is believed that advances in both ultrasound and Ophthalmodynamometry technologies will now enable the creation of such a device. Performance Objectives: Ability to provide rapid assessment of intracranial pressure elevation is of primary importance; device should be hand held or easily man portable, emphasis on minimal size and weight; ability to detect cerebral vascular flow, cerebral perfusion pressure, blood oxidation and intracranial hemorrhage are desired but not mandatory. The system would need to be validated by comparison with the gold standard of invasive ICP monitoring; The system should be capable of producing multiple measurements over time which are consistent and reproducible; Patient position should not impact measurement. The device should be capable of performing measurements without repeated calibration, providing consistent measurements from patient to patient. The device should be capable of being used on both conscious and unconscious patients.

Background: From previous wars, it has been estimated that approximately 20% of all military casualties have sustained a brain injury [9], and in a recent study of 155 injured soldiers returning from Iraq, 62% were found to have a brain injury [10]. This dramatic increase has been attributed to improved body armor—leading to a higher survival rate in blast injuries—and improved diagnosis of mild and moderate traumatic brain injury once a soldier has been evacuated. Improved diagnosis of TBI during the early posttraumatic period will significantly reduce the risk of secondary ischemic injuries and reduce mortality and morbidity of TBI.

PHASE I: Analyze the problem of field-based ICP monitoring and determine technical feasibility of an ultrasound or Ophthalmodynamometry-based system capable of monitoring intracranial pressure according to the performance objectives noted in the topic description. Develop engineering specifications and if feasible develop a prototype system. Deliver a report of the technical feasibility and engineering specifications to include a description of plans for performance objectives and validation for phase II execution. This includes the preparation of plans and protocols for any required animal or human testing as well as seeking local and Army regulatory approvals for potential phase II work.

PHASE II: Build a prototype man-portable or handheld battlefield TBI diagnostic and monitoring system, refine any additional performance objectives met in phase I and conduct system tests on appropriate animal and phantom models. Validate the system by demonstrating equivalence to invasive monitoring. If capable, conduct human clinical trials and obtain FDA approval for use.

PHASE III: Transition the capability to dual use in civilian and military emergency departments/Forward Surgical Teams/Combat Support Hospitals, and with military and civilian medical first responders. For example, the device could be used by paramedics at the site of injury to allow for immediate neuroprotective care to be provided. Data could be forwarded verbally or via wireless communications from the device itself to neurosurgical experts for real time consultation in the field.

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KEYWORDS: ultrasound, ophthalmodynamometry, traumatic brain injury, intracranial pressure, monitor

A06-152 TITLE: Insecticide Matrix Formulations for Improved Control of Sand Flies and Mosquitoes in Severe Environments

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop an insecticide formulation delivery matrix with superior residual properties and stability in environments characterized by high temperatures, intense sunlight, and blowing sand and dust that can be used by Preventive Medicine detachments during deployments.

DESCRIPTION: a) BACKGROUND: Vector-borne diseases such as leishmaniasis and malaria continue to threaten the health of deployed military personnel. These diseases are widely distributed throughout the world and, although vaccine development is a research priority, there are no available vaccines for many of these diseases. The impact of vector-borne illness to deployed forces is enormous. Over 1200 individuals from Operation Iraqi Freedom have required treatment for leishmaniasis since the beginning of the war in 2003. Standard preventive deterrence against arthropod-borne disease incorporates area vector control in conjunction personal protection methods. Military Preventive Medicine Detachments and contractor vector control personnel are responsible for vector control services in theater.

Vector control personnel in Iraq aggressively attempt to control sand flies, the vector of leishmaniasis. In some areas of Iraq, repeated failures of conventional pesticide applications to suppress vector sand fly populations were observed. The severe environmental conditions of Iraq may contribute to control failures. We suspect that the effects of intense heat, blowing sand and dust, ultraviolet light, or a combination of these and other environmental factors result in a lack of adequate control against sand flies.

Inadequate vector control raises several significant concerns. Reduced observed efficacy alone suggests that troop health continues to be potentially compromised despite the use of pesticides. Additionally, failure to achieve suppression of vector populations may result in additional chemical applications that potentially contribute to other vector control problems. Repeated pesticide usage is an immediate health threat to the vector control personnel that mix and apply the chemicals as well as to non-vector control personnel in the area. Furthermore, multiple treatments create additional expenses and may contribute to insecticide resistance problems in the future.

The goal of this SBIR is to encourage development of an insecticide application matrix that uses novel formulation technology for control of sand flies and other biting flies (including mosquitoes) and maintains stability at a wide temperature range (-32o C to >65o C). This formulation will demonstrate superior efficacy when compared to conventional pesticide applications in harsh environments like Iraq and Afghanistan. The development of this product will provide Preventive Medicine Detachments and contractor pest control personnel with superior vector suppression capabilities to reduce the threat of vector borne disease.

b) REQUIREMENT: The insecticide delivery matrix to be formulated should provide control of mosquitoes and sand flies at higher temperatures when compared to current Environmental Protection Agency (EPA) registered pesticides used in contingency operations. It should be stable above temperatures of 50o C (122o F), tolerate exposure to intense sunlight and require no additional handling requirements than pesticides already in use. The formulation should be stable in environmentally-stressed environments and should not present the user with higher levels of exposure or toxicity than conventional insecticide applications currently available in the contingency pesticide list.

c) DESIRED CAPABILITY/CONCEPT OF THE FINAL PRODUCT: We envision a formulation matrix that is applicable with standard pest control equipment and effective in environments characterized by high temperatures and intense sunlight. The goal is to suppress vector populations under environmental conditions found in Iraq and Afghanistan.

PHASE I: Selected Contractor proposes new insecticidal products through development of new chemistries, formulations, application materials and methods, or a combination of these components. Selected Contractor has flexibility to choose the areas of insect control technologies most appropriate to address the solicitation. Selected Contractor demonstrates suitability of the prototype formulation(s) or matrix model to meet performance requirements as discussed in this topic and produces technical industrial specifications of the product(s), if applicable.

PHASE II: Selected contractor demonstrates relevant properties of the novel product(s) meet requirements for further field testing. For prototype materials that will require Environmental Protection Agency (EPA) registration, the selected contractor will conduct testing of physical, chemical, and toxicological properties in accordance with EPA requirements.

PHASE III: This SBIR has strong commercialization potential. In Phase III, the selected contractor will obtain Environmental Protection Agency registration and successfully commercialize the product. This action supports application of the technology for both military and civilian operations. The participating government laboratory(ies) may advise or assist with field testing in support of trials applicable to product use in military operations. Government laboratories will provide feedback to the contractor regarding the efficacy of the product for suppression of vector populations. For military application, this Phase includes interaction with the Armed Forces Pest Management Board to obtain a National Stock Number for the product for use by military preventive medicine units and other personnel that conduct military vector control/pest management operations. For commercial application, registration of new products for vector control has considerable potential in the civilian public health sector. Moreover, development of novel pest management technologies is especially significant for the agricultural industry which holds the major interest in pesticide technology development and usage.

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KEYWORDS: vector control, insecticides, sand fly, mosquito

A06-153 TITLE: Neural Protein Biomarkers in the Blood for the Diagnosis of the Severity of Brain Injury

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: To identify neural biomarkers in the blood or urine to rapidly diagnose the severity and pathology of brain injury. Most specific biomarkers should be developed into a dipstick assay for field medical diagnosis of traumatic or closed brain injury and improved battlefield management of head injuries.

DESCRIPTION: Head injury which is a leading cause of combat casualties accounting for 25% of all battlefield injuries is diverse in its presentation. Primary injury triggers a cascade of secondary events involving metabolic failure and disruption of ion homeostasis leading to non-convulsive seizure and spreading depolarization that exacerbates the clinical outcome [1]. Neuronal hyperactivity and subsequent neuronal loss leads to cognitive deficits, impaired memory, judgment and perception. In the United States, the incidence of head injuries admitted to hospitals is conservatively estimated to be 200 per 100,000 population, and the incidence of penetrating head injury is estimated to be 12 per 100,000, the highest of any developed country in the world [2;3]. Unlike the penetrating brain injury, closed head injury observed with many of the injuries to US troops in Iraq caused by improvised explosive devices and rocket propelled grenades, are more difficult to detect. The vast majority of casualties returning from Iraq to the Walter Reed Army Medical Center suffer from closed head injury, which is 20% higher than previous conflicts. This trend that could reflect not only the type of warfare they're encountering but the protective gear they wear (Steven Vogel, Washington post Sunday December 14, 03). Most likely, increased incidence of blast or projectile impact with protective helmets yield closed head injuries. Closed brain injuries are often triaged as not being as important or life threatening as more obvious cases of trauma, although they cause a broad range of physical, cognitive, emotional, and social problems for the victims [4-6]. With early detection, treatment, and therapy many victims of head injury can be expected to recover fully.

Pathological changes that occur in the brain soon after head injury leads to clinical worsening [7]. Thus, a rapid and accurate identification of patients with brain injury is considered critical to the successful treatment and management of the battlefield wounded. Early diagnosis and treatment of brain injury must occur on the battlefield itself or in far-forward combat locations to be effective. A blood-based method, such as an antibody-based dipstick, could provide a practical instrument for the accurate and early diagnosis of brain injury the battlefield. The use of the biomarker assay could serve as a valuable method for accurate, rapid, and far-forward field diagnosis of head injury and permit the timely prophylactic treatment of secondary lesions and post-traumatic seizures.

In recent years, there have been many studies to investigate biological markers of injury to the central nervous system (CNS). CNS biomarkers generally represent proteins that are specifically produced in the brain and spinal cord and relatively sequestered in the central nervous system mainly due to the presence of an intact blood-brain barrier [8;9]. When the blood-brain barrier is damaged due to brain injury or disorders, brain proteins can be released into the circulation and accumulate in the blood. The detection and quantification of CNS-specific proteins released into the blood as the result of brain injury, therefore, provides a potentially attractive means of diagnosing brain injuries using a minimally invasive procedure [10].

Although the highly orchestrated cellular and molecular post-traumatic changes have not yet been fully elucidated, it is known that brain injury triggers a cascade of events that results in alteration of cerebral blood flow and metabolism, tissue edema, neuronal degeneration and finally cell death (5;6). Studies suggest the early occurrence and importance of reactive oxygen species formation and subsequent oxidative damage as a major factor responsible for various pathological responses following injury [11;12]. Oxidative damage in the CNS manifests itself primarily as lipid peroxidation since this organ is rich in peroxide sensitive fatty acids and has a scarcity of antioxidant scavengers. A number of reports also suggest that oxidative damage plays a significant role in the neuropathology following chemical or biological warfare agent exposure [13;14].

Isoprostanes are chemically stable end-products of free-radical induced oxidative modification of lipids that accumulate in tissue and circulate in plasma and are excreted in urine. Large number of studies have shown that they represent specific and sensitive markers of in vivo lipid peroxidation and oxidative damage following injury [15], suggest that measurement of F2-Isoprostanes (F2-IsoP) may provide a reliable marker of brain injury mediated lipid peroxidation in vivo. First, these are stable compounds very specific for lipid peroxidation. F2-IsoPs have been found to be present at a consistent level that is detectable in all normal biological tissues and biological fluids. This allows the definition of a normal range such that small increases in their formation can be detected in situations of mild injury-mediated oxidant stress. Notably, F2-IsoPs could increase in injuries that may not change the blood-brain barrier function and could be an indicator of minimal head injury. Most important, the formation of F2-IsoPs has been shown to increase dramatically in well-established animal models of traumatic brain injury and many neurodegenerative disorders [16-20]. Additionally, urinary levels of F2-IsoPs in subjects ingesting a normal diet were unchanged after 4 d of a diet consisting of only glucose polymers. Measurement of F2-IsoPs in urine or plasma after brain injury could provide a noninvasive surrogate marker to study the severity of brain damage and to investigate the therapeutic effects of neuroprotective drugs in the clinical condition. Identifying a quantifiable specific neural biomarker of brain injury in the blood or urine that correlate with the seriousness, time course and neuropathology will be invaluable for the combat medic managing head injury casualties.

PHASE I: Develop ELISA assays for potential neural biomarkers (for examples, S-100 beta, neuron specific enolase, MAP-tau, cleaved tau, myelin basic protein, glial fibrillary acidic protein, secretagogin, synaptophysin) in the blood and/or urine F-2isoprostanes and determine the sensitivity.

PHASE II: Using the sensitive ELISA assays determine the levels of potential neural biomarkers in the blood and/or urine in brain injury models (traumatic brain injury or closed head injury) to obtain the proof of concept. Correlate the neural biomarker in the blood with the severity and time course of the injury. Investigate the level of the biomarker following medical treatment of brain injury to evaluate the prognosis of therapy and recovery. Refine the most promising biomarker assay as a dipstick assay.

PHASE III: The neural biomarker dipstick assay can be used in civilians to assess brain injury following non-penetrating head trauma and to evaluate therapeutic prognosis of head injury. With in the military, the dipstick assay could be used for battlefied diagnosis of non-penetrating head injuries or brain damage following nerve agent poisoning.

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KEYWORDS: neuronal markers, traumatic and penetrating brain injury, diagnosis of brain injury, protein markers, severity of injury

A06-154 TITLE: Pharmacological Strategies for Prevention and Treatment of Noise-Induced Hearing Loss

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop a procedure that will predict cochlear pharmacokinetics of otoprotectorants by analyzing pharmacokinetics in the general circulatory system. This information for an agent will help delineate dosage parameters and the therapeutic window for pharmacological treatment of noise-induced hearing loss. Also determine the most practical delivery method for Soldiers in the field. Evaluate the effectiveness of otoprotectorants on permanent noise-induced hearing loss.

DESCRIPTION: In order to see first, understand first, act first, and finish decisively, the Soldier has to hear first. Furthermore, the sense of hearing is described as the most important survival sense for the dismounted Soldier (Letowski, 2003). Noise-induced hearing loss (NIHL) is a major contributor to decreased operational effectiveness. Existing barrier technologies (e.g., earplugs, earmuffs) cannot reduce the noise levels from modern weapon systems to levels that do not cause NIHL. For example, in a recent study, it was reported approximately 11 percent of Marines suffered permanent NIHL during recruit training in spite of rigorous hearing conservation practices (Taggart et al., 2001). Furthermore, barrier technologies are frequently not used in combat due to their effects on operational requirements (e.g., speech communication, signal detection and recognition, etc.). For example, the USMC Center for Lessons Learned concluded that command and control (C2) during the battle of Falluajh was lost as the result of NIHL from exposure to noise from high-intensity combat operations (MCCLL, 2005). In other words, C2 + Noise-induced hearing loss = C-zero. Thus, non-traditional solutions must be found to protect the Soldier from the noise from his own weapons.

The hearing loss statistics from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) are staggering. Hazardous noise exposure is the greatest in over 30 years and compliance with hearing conservation requirements is poor. As a result, the prevalence of NIHL is increasing with Army disability claims increasing after 14 years of decline and with the increase in Army claims in 2004 having highest percentage increase in over 18 years.

One of the major sources of injury among operational forces is from blasts (e.g., rocket-propelled grenade, mortar, improvised explosive device). It has been reported that 64% of blast-injured Soldiers seen at Walter Reed Army Medical Center have some hearing loss and 28% of all Soldiers who have deployed have hearing losses or report tinnitus. The percentage of Soldiers with H-3/H-4 hearing levels [indicating either non-deployable status or a possible (likely) inability to perform duties] is over 33% for those who have deployed to OIF and OEF compared to less than 6% of non-deployed Soldiers.

Recent advances in the understanding of the biochemistry of the ear have resulted in the discovery of pharmacological agents that can prevent and treat NIHL. The impact of these discoveries cannot be underestimated. A pharmacological strategy for the prevention of and treatment of NIHL is essential for operational effectiveness, survivability, sustainability, and retention of a fit Future Force.

PHASE I: Develop a procedure for determining the relationship between pharmacokinetic attributes of an agent known to affect noise-induced hearing loss and the agent’s pharmacokinetic characteristics in the cochlea.

Pharmacokinetic measures should include (but are not limited to) maximal serum plasma concentrations, time to reach maximal levels, and determination of the half-life of the agent in both the cochlea and. Develop or identify a method of delivery that will provide the safest, fastest, and most practical way to introduce the agent to the cochlea.

The product of Phase I will be an assessment procedure and a delivery method.

PHASE II: Using an animal model, finalize and validate the procedure and delivery method identified in Phase I by measuring maximal serum plasma concentrations, time to reach maximal levels, and the half-life of the agent in both the cochlea and the general circulatory system. Use at least two agents with a Technical Readiness Level of 5 or greater (e.g., N-acetylcysteine, D-Methionine, and Ebselen/SPI-1005). Other agents may be included.

The delivery method should be able to be implemented on Soldiers in the field (e.g., not require invasive medical procedures, be resistant to harsh environments, etc).

As part of the procedure and delivery method validation, assess the effect of the agents on permanent noise-induced hearing loss. Dependent measures must include electrophysiological thresholds and anatomical (e.g., hair cell) measurements.

PHASE III: Results of Phase I and Phase II efforts will identify the most efficacious pharmaceutical and delivery method for use in prevention and treatment of noise-induced hearing loss. Following that identification, human clinical trials may begin for eventual FDA approval. Hearing loss is an enormous problem for the U.S. Army and an FDA-approved drug that reduces hearing damage could prevent Soldier attrition and reduce funds spent on treating hearing loss in veterans. Hearing loss also is a problem in the civilian sector and a "hearing pill" would find a large civilian market.

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KEYWORDS: noise-induced hearing loss, drug, pharmaceuticals, protection, treatment

A06-155 TITLE: Automated Laser Debridement System for Cutaneous Injuries

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Design and manufacture an automated system that will scan large areas of a casualty’s body that are in need of wound debridement following a skin injury, and perform the debridement. Instrument will encompass erbium:yttrium-aluminum-garnet (Er:YAG) laser technology and allow the attending physician to program the instrument to debride specific areas of damaged tissue. Physician should be able to interactively circumscribe the treatment areas on a video screen and enter operating parameters of the laser. Instrument will then quickly and automatically perform the debridement.

DESCRIPTION: Thermal burns and vesicating (blistering) chemical warfare agents (such as sulfur mustard and Lewisite) induce skin injuries which can vary in severity between second degree and third degree. Vesicant injuries in particular can take several months to heal, necessitate lengthy hospitalizations, and result in significant cosmetic and/or functional deficits. Recent advances have been made in improving the healing of thermal and chemical burns using a variety of techniques to debride (remove) damaged tissue, including the use of medical lasers. Additionally, leg ulcers (e.g., venous stasis ulcers, pressure ulcers, diabetic foot ulcers) and penetrating injuries to the skin can require frequent debridement to help these wounds to heal; laser debridment may be of great benefit in these areas as well.

There are a number of lasers manufactured in the U.S., Canada, and Europe that could be considered for routine debridement of skin injuries or diseases. Acland and Barlow have recently provided a review on the current uses of lasers in dermatological practice and list the types of lasers used for specific procedures. They list CO2 and Er:YAG lasers as being the most appropriate for cutaneous resurfacing. Er:YAG lasers have been used for a wide variety of procedures, ranging from facial resurfacing to burn debridement. They have been shown to be particularly useful in the debridement of partial-thickness thermal burns and in the management of deep Lewisite injuries. Unlike the Gaussian beam profiles created by CO2 lasers, Er:YAG laser beams tend to be uniform and produce uniform depths of ablation.

One drawback to laser systems on the market today is that they require the surgeon to move a hand piece over the damaged area, which can be time consuming given an injury with a large surface area. The design of small hand held scanners on the ends of articulated arms has weakened this drawback to a limited extent; the scanned areas are relatively small and the surgeon still needs to move the scanner head over the large injuries. A time savings could be realized with a system that could scan very large areas of a patient’s body and perform precise debridement automatically with minimal surgeon involvement. Such a system would greatly decrease medical logistical burden, especially in a mass casualty scenario.

Robotic efforts in the field of surgery are not new. Cardiac and laproscopic surgery have benefited through the innovative creation of robotic instruments. The Department of Defense attempted to have built such an automated system for burn surgery in the mid-1990s. The laser that was developed was the TX1A Burn Debridement Laser System, a prototype system developed by the Wellman Laboratories of Photomedicine, Massachusetts General Hospital (Boston, MA). The TX1A was a computer controlled, raster scanned, continuous wave CO2 laser system. The optical system was designed to deliver 150 Watts of laser radiation to the target site with a 1.5-mm spot size, a depth of focus of +/- 51 mm (Rayleigh distance), and an average irradiance of 8.5 kW/cm2. The laser beam was controlled with an x,y-scanner, and the speed was adjusted to keep the fluence constant at 35 J/cm2. The system was designed to accommodate a relatively large (20X20 cm) field of view. Through user-friendly interactive software, the surgeon defined the region of debridement, allowing him to interactively circumscribe the treatment areas on a video screen and enter operating parameters of the laser (including number of passes of the laser beam to be taken). The instrument then went on to debride a large area of tissue to the surgeon’s specification. Early experimental use of this type of instrument in human thermal burn patients and research pigs exposed to chemical or thermal insult demonstrated promising results in helping these injuries to heal quickly (reference articles by Sheridan, Glatter, and Graham). There were several disadvantages to the TX1A prototype system, however, including its weight and lack of a self-contained cooling system. This instrument was never commercialized, nor are there any similar ones on the market today.

There is a need to revisit this type of robotics that incorporates modern laser technology (e.g., Er:YAG), is user friendly, and can be used to debride cutaneous wounds of a wide variety of etiologies (e.g., thermal or chemical burns, leg ulcers, penetrating injuries). Such a system could be used in both forward field hospitals and upper echelon medical facilities. Robotic surgery is the wave of the future, allowing medical personnel to perform minimally invasive and automated surgery in a timely and accurate manner. Design of such a system to debride skin injuries using up-to-date computer, laser, and mechanical engineering technologies is expected to be technically challenging, and will require innovative and creative approaches to meet the technical goals. Significant flexibility in formulating an approach will be afforded.

PHASE I: Develop design of an automated laser debridement system. Electronic engineering plans should be generated that allow 3-dimensional, rotational views of all components of the proposed system. A document describing the proposed operation and functionality of the system should also be generated.

PHASE II: Develop and demonstrate efficacy of a prototype system. Conduct in-depth testing in an appropriate animal model to show functionality.

PHASE III: This system could be used in a broad range of military and civilian medical settings. The debridement system would benefit military and civilian patients suffering from vesicant burns, thermal burns, or a variety of skin conditions or injuries that require debridement.

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KEYWORDS: laser, debridement, vesicant, sulfur mustard, thermal injury, burn, ulcer, trauma, wound healing

A06-156 TITLE: Long-lasting Insecticide-impregnated Bed Net

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop a portable, light-weight, self-supporting, long-lasting insecticide-impregnated bed net that optimizes a large mesh with a low insecticidal dose to provide protection for deployed soldiers against biting disease vectors.

DESCRIPTION: Bednets provide excellent protection against insect-borne diseases such as malaria, dengue, and leishmaniasis. Two types of insect bednets are currently available though the Defense Logistics Agency (DLA). The standard insect bednet (NSN 7210-00-266-9736) has a variety of limitations associated with it, to include: a) it is not impregnated with a repellent, b) it requires four 36" poles to set-up, c) it is difficult to enter and exit, and d) it must be properly tucked in on all sides to prevent biting insects from entering. It is estimated that this bednet accounts for 95% of all requisitions. The Self-Supporting Low-Profile (SS-LP) bednet (NSN 3740-01-516-4415 [woodland green] and NSN 3740-01-518-7310 [coyote brown]) has none of the limitations associated with the standard bednet. It is a light-weight, self-contained bednet with an integral self supporting frame. The SS-LP bednet folds into a 12 inch diameter package.

The SS-LP bednet is intended for short-term use by rapidly deployable forces that are extremely mobile (e.g., infantry, rangers, special forces, etc.). Although it is an ideal product for this purpose as it is light and easily set-up and taken down, the SS-LP bednet is not ideal for longer-term use, as it is small and can feel claustrophobic.

The goal of this project is to develop an improved bednet that soldiers are willing to use on a routine basis. The improved bed net should protect against all biting insects, should have a mesh large enough to permit air flow (lack of air-flow is a major reason why soldiers will not use insect bed nets), and should be a design that soldiers are willing to use on a long-term basis.

Specific requirements for the improved bed net are: i) should be be constructed of a material that will maintain its physical and insecticidal integrity for at least 5 years of continuous use, ii) the netting should be a rip-stop fabric, iii) the net must be treated with an EPA-approved insecticide, iv) the bed net must not require re-treatment with insecticide after washing or prolonged exposure to direct sunlight (UV radiation), v) the net must be designed so that a standard Army cot fits inside it, should be tall enough that a soldier can comfortably sit on top of the cot, should have a zippered entrance that can be operated from inside or outside the net, should include a self-contained flooring, able to be erected in under 5 minutes, and should weigh less than 3 pounds, vi) the frame should be constructed of a material that is flexible and durable.

PHASE I: Selected contractor determines the feasibility of the concept by developing an initial prototype insect bed net that has the potential to meet the broad needs discussed in this topic. A final report shall be delivered that specifies how Phase I requirements were met. There is technical risk to this effort, in that no product exists that currently meets the objectives described in this topic -- there are multiple approaches that could potentially yield a product that meets the requirements of this topic. The challenge will be to develop a insect bed net that provides protection from the entire range of disease-carrying insects (mosquito, sand flies, ticks and chiggers) while at the same time being accepted by the user and meeting requirements for registration by the Environmental Protection Agency.

PHASE II: The selected contractor conducts iterative improvements to the bed net until a final prototype is developed that meets the requirements of this SBIR topic. During Phase II the contractor will conduct laboratory and field evaluations against multiple vector species (mosquitoes, sand flies, etc.), to include a user acceptability trial that compares the developed product with the standard insect bed net and the SS-LP bed net. At the conclusions of Phase II the selected contractor will also provide the COR with 100 candidate bed nets for independent testing at the Walter Reed Army Institute of Research in Phase III. Once a candidate bed net has been developed that meets the criteria outlined in this proposal, the selected contractor should conduct testing of physical, chemical and toxicological properties of the bed net in accordance with EPA requirements.

PHASE III: This SBIR project has strong commercialization potential (customers include US and allied military forces, a variety of people who spend time outdoors in the US [e.g., hunters, campers] and a wide range of people who are exposed to vector-borne diseases in developing countires).

Under Phase III the selected contractor will complete studies required to obtain EPA registration for the product and will successfully commercialize the bednet, to include working with the Armed Forces Pest Management Board to obtain a National Stock Number for the bed net.

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KEYWORDS: Insect Bed Net, Sand flies, Mosquitoes, Protection

A06-157 TITLE: Liquid-Fueled Catalytic Heater for Infusion Fluids

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop a lightweight and compact portable warming device that uses a catalytic combustion system based on a liquid fuel to generate heat for warming infusion fluids. The device will warm cold infusion solutions or red blood cell units to body temperature in a regulated fashion.

DESCRIPTION: Military personnel injured in remote locations must often be treated with limited medical resources. A significant concern for casualties that require fluid resuscitation is that the infused fluid can cause hypothermia that leads to pathophysiological alterations in blood coagulation. A need exists for a lightweight, portable device that can be used at the immediate site of injury to warm infusion fluid during resuscitation. A liquid-fueled catalysis-based warmer would have advantages for this application because such a device does not require line or battery electrical energy for heating. For instance, a currently fielded battery heated infusion fluid warmer can warm 1 to 3 units of blood from an input temperature of 10 degrees C to 38 degrees C. To do this requires a fully charged battery that weighs 6.25 pounds. The military is under continuous pressure to reduce the volume, weight, and size of items deployed to support troops in the field. Liquid fuel has a much higher energy density than batteries and will allow more warming capability per unit weight. An effective infusion fluid warmer will enhance medical care capabilities of far-forward and theater medical care units while dispensing of the need for bulky batteries that require recharging or replacement with a liquid fuel. It is envisioned that the fluid warmer will also have significant utility for assisting in medical care in developing countries, rural areas, disaster areas, or other scenarios where fluid warming resources are not readily available.

PHASE I: Develop and test a functional prototype device assembled from “off-the-shelf” components that uses a liquid fueled catalytic heater to warm a saline solution such as Lactated Ringers from refrigerator to body temperature. The fluid flow rate (from gravity feed or an external pump) should be at least 50 ml/min and output temperature should exceed 34 degrees C. The infusion fluid warmer will utilize a liquid fuel such as methanol as an input into a membrane catalytic heating core that will warm infusion fluids transiting the device. Output fluid temperature should be regulated to within 2 degrees C of an adjustable set point. The device in its final packaging should be rugged, compact, and portable.

PHASE II: Develop and test a portable fluid warmer prototype in fieldable form and demonstrate the system to interested end-user communities within the Army and other military branches. The system should be capable of meeting the basic requirements detailed above, with an increase in capability to attain approximate body temperatures (34 -37 degrees C) with a flow rate of at least 100 ml/min from cold fluid (5 – 6 degrees C). The shelf-life of the liquid fuel feedstock for the catalytic heater should be documented to exceed one year.

PHASE III DUAL USE APPLICATIONS: Operating rooms, mobile veterinary practices, developing countries and aid agencies, homeland security response teams, and de-centralized medical facilities all have a need for a portable infusion fluid warmer with the ability to warm any infusion fluid in austere environments.

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KEYWORDS: portable fluid warming system, catalytic combustion, medical, hypothermia, infusion, blood

A06-158 TITLE: A Multiplexed Point-of-Care Assay for the Detection of Enteric Pathogens That Cause Severe Diarrhea in Deployed Soldiers

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Adapt state-of-the-art technology to develop a field-usable assay capable of detecting and identifying enteric pathogens in stool samples.

DESCRIPTION: Diarrhea is the leading cause of morbidity in deployed soldiers – rapid identification of the pathogen causing the diarrhea is required in order to initiate appropriate treatment and to minimize the impact of the disease on our operational capabilities. In order to minimize medical evacuation and lost-duty time, identification of the pathogen should occur as far-forward as possible.

The goal of this SBIR topic is to develop a rapid, multiplexed detection assay capable of simultaneously determining whether a given stool sample is infected with E. coli O157, Campylobacter sps., Cryptosporidium sps., Salmonella sps., Shigella sps., Noraviruses and Rotaviruses. 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 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 conducts initial studies to demonstrate that a diagnostic assay that has the potential to meet the broad needs discussed in this topic is feasible. At the conclusion of Phase I, the selected contractor provides a data packet to the COR that describes the work that has been accomplished and how this supports the overall objectives of the topic.

Selected contractor should coordinate with the COR for potential access to reagents and positive control material from the Walter Reed Army Institute of Research (WRAIR) or the Naval Medical Research Center (NMRC) if such support is desired. A limited supply of reagents and positive control material may be provided at no cost to the SBIR contractor (these reagents may not be sufficient to complete all work required by the contract – the contractor may have to obtain additional reagents from a source other than WRAIR or NMRC).

PHASE II: In Phase II the selected contractor develops prototype assay(s), conducts testing and evaluations and makes iterative improvements to the assay until requirements described above are met. The goal in Phase II is the development of an assay that provides 80% sensitivity and 80% specificity when compared to current gold standard assays for each particular pathogen (see list of pathogens above). Once sensitivity/specificity requirements have been met, the selected contractor conducts studies that lead to the development of a data package (e.g., a 510(k) application) that can be submitted to the FDA. At the conclusion of Phase II, selected contractor provides 200 prototype assays to the COR for testing at the WRAIR during Phase III.

PHASE III: During Phase III the selected contractor completes studies required to obtain regulatory approval from the FDA and successfully commercializes the assay. WRAIR and NMRC laboratories may be able to assist the contractor in the completion of these studies; however, this assistance must be coordinated in advance.

In addition to filling a critical requirement for the military during deployments, the enterics assay that is developed will have extensive dual-use applications. Diarrheal diseases are a leading cause of illness and death throughout much of the world (diarrhea is the leading killer of young children in many countries). The developed assay would have widespread use by national and international public health organizations as well as by Non-Governmental Organizations (NGOs) seeking to minimize the impact of diarrheal diseases.

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KEYWORDS: Enteric pathogens, diagnosis, devices, multiplex

A06-159 TITLE: <u>Rapid Detection of Acetylcholinesterase-Inhibiting Pesticides in Water</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: The objective is to develop a rapid, reliable, sensitive assay for detecting acetylcholinesterase-inhibiting pesticide compounds in water. Advances in this area will help provide rapid identification of potential health effects on deployed forces resulting from waterborne exposures to a wide array of toxic chemicals.

DESCRIPTION: As part of a research program to identify environmental hazards to soldiers resulting from exposure to toxic industrial chemicals, the U.S. Army Center for Environmental Health Research (USACEHR) and the Joint Service Agent Water Monitor Program at the U.S. Army Research, Development & Engineering Command are seeking new methods for rapidly identifying toxic levels of acetylcholinesterase-inhibiting pesticides in water samples. We are seeking innovative and creative research and development approaches applicable to a broad range of organophosphate and carbamate pesticides.

PHASE I: Conduct research to provide a proof of concept demonstration of a rapid, reliable, and sensitive test for acetylcholinesterase-inhibiting pesticides in water samples. The concept will be original or will represent significant extensions, applications, or improvements over published approaches. Design and performance considerations for a proof of concept demonstration are listed below.

1. The method will have the potential to identify acetylcholinesterase inhibition associated with both carbamate and organophosphate pesticides. Ideally, detection limits will approximate published Military Exposure Guidelines (MEGs) (USACHPPM, 2004). Responsiveness should be demonstrated with three MEG chemicals (two organophosphorus and one carbamate pesticides); appropriate sensitivity will be evaluated with respect to the corresponding 7-14 day MEG concentration for water assuming 15 liter (L)/day consumption. Example chemicals (with MEG concentrations) include aldicarb (0.005 milligram (mg)/L), methamidophos (0.002 mg/L), and methyl parathion (0.15 mg/L).
2. Detection must occur within 60 minutes of test initiation; preference will be given to detection methods with response times of 15 minutes or less.
3. Assays with the following additional characteristics are preferred:
   a. Linear concentration-response curve over a wide range of concentrations.
   b. System components compatible with or reducible to a hand-held unit.
   c. Minimal sample processing steps and reagents.
   d. Long component shelf lives with minimal requirements for environmental control (temperature, humidity, etc.).

PHASE II: Expand upon the Phase I proof of concept demonstration to construct a soldier-portable prototype detection device. Show the device sensitivity with respect to the 7-14 day, 15 L/day MEG concentration for water with at least 12 organophosphate and carbamate pesticides. Detection limits should be determined using a Receiver Operator Characteristic (ROC) Curve approach (Beck and Shultz, 1986). Demonstrate a detection limit that will not exceed a 5% false alarm rate (false negative 5% rate/false positive 5% rate) in water matrices typical of Army field water supplies. The device should be designed to facilitate transportation and maintenance (with minimum logistical requirements), ease of exposure to water samples, and straightforward data interpretation. Provide two detection devices for independent evaluation and testing.

PHASE III: Determine the ability of the detection device to evaluate drinking water for deployed troops under field conditions. Field tests will involve testing at Army water production facilities. Given current on-going concerns regarding accidental or intentional contamination of water supplies, this technology will have broad application for water utilities as well as state and local governments. A well-formulated marketing strategy will be critical for success in these commercial applications.

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KEYWORDS: rapid toxicity identification, carbamate pesticides, organophosphorus pesticides, acetylcholinesterase inhibitors, toxic industrial chemicals

A06-160 TITLE: Diagnosis of Bone Fractures and Soft Tissue Injury with a Non-invasive Non-ionization Imaging Technique

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: The objective of this topic is to develop a high-resolution C-scan ultrasound imaging device to investigate abnormalities on the bone surface such as subtle fractures and foreign objects in soft tissues.

DESCRIPTION: There is a need for a system to investigate undisplaced fractures of the facial bones and extremities and the potential contamination of soft tissue wounds with foreign matter to decide on the need for medical evacuation to a higher level treatment facility. Injury with pain and tenderness without fracture could often be treated locally while a facial fracture would require evacuation. Foreign matter in superficial wounds needs to be identified and removed. Standard ultrasound is difficult for the novice to interpret. X-ray facilities are often limited far forward. A small lightweight portable ultrasound system for the identification of undisplaced fractures and foreign matter in soft tissue wounds would aid in the decision for or against medical evacuation.

In use, this device must be safe and must meet requirements for battlefield use (i.e., be low-weight, low-volume; require only battery power, require minimal or no mixing of components; able to be stored/used at environmental temperature) by medical personnel at the training level of combat medics.

PHASE I: Feasibility study or laboratory setup to demonstrate that a C-scan based ultrasound system is capable of imaging soft tissue and bone surface. Successful completion of Phase I will result in development of a non-invasive imaging device that could show injury of soft-tissues, identify foreign matter and bone fractures. Preliminary “proof-of-concept” experimentation in ex vivo models or tissue simulator (phantom) is desired for demonstration of efficacy.

PHASE II: Develop a pre-clinical ultrasound device based on the Phase I experiments. Perform preclinical testing in animal models of trauma. Requirements for successful completion of this phase include successful use in a well-controlled animal study using a standard model of injury such as small foreign object in soft tissue and small fractures on bone surface. Successful completion of Phase II will result in a speckle-free ultrasound device that is ready for entry into clinical studies.

PHASE III DUAL USE APPLICATIONS: Because of the high incidence of bone fractures and foreign objects in the soft tissue associated with both military and civilian trauma, an effective portable imaging device would have wide applicability in trauma centers throughout the world. Furthermore, the physical and functional characteristics of this device support its use for medical imaging applications in less developed locations, such as on-site or regional hospital emergency care.

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KEYWORDS: fracture, bone, ultrasound, imaging

A06-161 TITLE: Multi-purpose Compressor-Decompressor (CODEC) with Telesurgery Capability

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop and design a multi-purpose CODEC to provide telesurgery, telementoring, and store-and-forward teleconsultation to the battlefield. This new CODEC must be flexible enough to operate across various network configurations and reliable over a very large range of bandwidths. The CODEC must dynamically optimize network configuration within the current theater of operations. Sudden alternations in communication capabilities that routinely occur within theater mandate a CODEC with graceful degradation of service. The concerns of compression latency and communication component prioritization (e.g. audio over robotic over multiple video signals) must be considered. This CODEC must be capable of being utilized independent of the Quality of Service available (e.g., amount of bandwidth available dictates store-and-forward consultation or stereoscopic telerobotic surgery).

DESCRIPTION: Computer technology is utilized in nearly every type of industry and is growing in acceptance in healthcare as well. A particular area in healthcare in which there is a significant military and civilian interest is telemedicine. Telemedicine utilizes electronic information and communication technologies to provide and support health care over distances separating patients and providers. Telesurgery is a subset of telemedicine which the military has a significant interest. Through use of a surgical robot and telecommunication link, telesurgery allows an expert surgeon to operate on a remote patient. Advancements in such “tele-technologies” could save the lives and limbs of our war fighter.

As the military has numerous members stationed in disparate locals and extreme environments, it is faced with a unique medical challenge -- to provide quality healthcare on the battlefield as well as hospitals spread across the world. This diverse healthcare mission requires technologies that support such capabilities as high resolution diagnostic imaging, interactive video mentoring of procedures and asynchronous store-and-forward consultation (i.e., e-mail consultation that can be sent and retrieved on demand). Potential military applications of telemedicine range from a simple phone call to a healthcare provider in one’s home state to emergency telerobotic surgery provided by an expert CONUS surgeon to a critically injured soldier in Iraq. Telesurgery will be of great benefit if the required technologies are developed to provide robust application. The telesurgery CODEC research is essential to help address unmet medical needs in healthcare on the battlefield and at home.

Military medical needs and constraints in battlefield resources mandate development of a telesurgery CODEC. The design of the telesurgery CODEC must offer solutions to reduce Control Latency (delay from when the distant surgeon moves a controller and the surgical tool moves in the body cavity), Visual Discrepancy (delay between when an object moves in the operative field and when the surgeon visually realizes the movement), Round-trip

Delay (sum of Control Latency and Visual Discrepancy) and Jitter (real-time variations in the amount of delay introduced by variable traffic in telecommunication networks). Mitigation of these communication parameters requires rapid digitalization and compression of the video signal(s) by the CODEC(s), optimal transmission of the signal(s) across telecommunication networks, and rapid decompression of the signal(s) by the remote CODEC(s). This CODEC must reliably operate over a range of bandwidths and network configurations. The CODEC must allow the care provider to manage the service provided based on available communication capabilities. Graceful degradation of service will facilitate robust care within the battlefield.

Teleoperation haptics between a 'master' controller and 'slave' effector are currently a significant challenge. Haptic sensation requires ~1000 updates per second. Multiplication of the speed of light (186000 m/s) times the minimum haptic update rate (1/1000 s) suggests a maximum haptic teleoperative distance of approximate 186 miles. Electron speed and other delays suggest that about 100 mile communication distance is feasible. As a haptic device requires round trip communication (sends position to surgeon and surgeon feeds back new position), haptic telerobotic surgery would be possible at an actual distance of ~50 miles. Limited available solutions such as predictive motion and bandwidth constraint can extend the distance of haptic teleoperation. These solutions should be incorporated into the CODEC as haptics will likely be a component of future telesurgical systems.

PHASE I: Conduct research and gather data focused on previous and current work in CODEC development to design a multi-purpose telesurgery CODEC. 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 the proposed CODEC. Identify design features and applications that will improve the 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 CODEC for telesurgery including the following advancements. Hardware and software that:
•Minimize impact of latency
•Support and permit management of multiple video, audio, and data streams
•Automatically optimize network configuration and performance
•Support stereoscopic vision
•Support haptics teleoperation between 'master' controller and 'slave' effector
•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 telecommunication and robotic systems
•Rapidly configurable to support battlefield use

PHASE III: The ultimate goal of this research is to provide a new multi-purpose CODEC in support of telesurgery capability to permit telesurgery, telementoring, and store-and-forward teleconsultation from Continental United States (CONUS) to the battlefield. The telesurgical CODEC will improve the 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 telesurgery technologies continue to advance the private sector will also adopt this. Telesurgery includes teleconsulting, telementoring, telestration, and etc. There are currently many instances in the private sector of consultation between specialists and generalists. Quality of Service(QoS) in telecommunication differs greatly within the private healthcare system, as well, depending upon geogrphical locations (urban vs. rural setting) and the existing telecom infrastructure. Cost within the private sector is a major factor in business decisions to implement telemedicine technologies. This new codec technology can mitigate bandwidth costs while providing a scalable telemedicine tool which clearly benefits the private sector healthcare equally as well as the DoD in improving the overall QoS.

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KEYWORDS: CODEC, Telesurgery, Teleoperation, stereoscopic, latency, multi-purpose

A06-162 TITLE: The Role of Micronutrients in Reducing Noise-induced Hearing Loss

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Evaluate at least two micronutrients for effectiveness in prevention of noise-induced hearing loss or tinnitus.

DESCRIPTION: In order to see first, understand first, act first, and finish decisively, the Soldier has to hear first. Furthermore, the sense of hearing is described as the most important survival sense for the dismounted Soldier (Letowski, 2003). Noise-induced hearing loss (NIHL) is a major contributor to decreased operational effectiveness. Existing barrier technologies (e.g., earplugs, earmuffs) cannot reduce the noise levels from modern weapon systems to levels that do not cause NIHL. For example, in a recent study, it was reported approximately 11 percent of Marines suffered permanent NIHL during recruit training in spite of rigorous hearing conservation practices (Taggart et al., 2001). Furthermore, barrier technologies are frequently not used in combat due to their effects on operational requirements (e.g., speech communication, signal detection and recognition, etc.). For example, the USMC Center for Lessons Learned concluded that command and control (C2) during the battle of Falluajh was lost as the result of NIHL from exposure to noise from high-intensity combat operations (MCCLL, 2005). In other words, C2 + Noise-induced hearing loss = C-zero. Thus, non-traditional solutions must be found to protect the Soldier from the noise from his own weapons.

The hearing loss statistics from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) are staggering. Hazardous noise exposure is the greatest in over 30 years and compliance with hearing conservation requirements is poor. As a result, the prevalence of NIHL is increasing with Army disability claims increasing after 14 years of decline and with the increase in Army claims in 2004 having highest percentage increase in over 18 years.

One of the major sources of injury among operational forces is from blasts (e.g., rocket-propelled grenade, mortar, improvised explosive device). It has been reported that 64% of blast-injured Soldiers seen at Walter Reed Army Medical Center have some hearing loss and 28% of all Soldiers who have deployed have hearing losses or report tinnitus. The percentage of Soldiers with H-3/H-4 hearing levels [indicating either non-deployable status or a possible (likely) inability to perform duties] is over 33% for those who have deployed to OIF and OEF compared to less than 6% of non-deployed Soldiers.

A confounding problem in the research on noise-induced hearing loss is the tremendous variability seen among research subjects exposed to the same noise signatures. One possible cause of these individual differences may be differences in levels of micronutrients in test subjects. Recent advances in the understanding of the biochemistry of the ear have resulted in the discovery of pharmacological and nutriceutical agents that can prevent and treat NIHL. The impact of these discoveries cannot be underestimated. A pharmacological strategy for the prevention of and treatment of NIHL is essential for operational effectiveness, survivability, sustainability, and retention of a fit Future Force.

PHASE I: Preparation and approval of a research protocol, for work to be conducted during Phase II, to evaluate the role of micronutrients in the susceptibility to noise-induced hearing loss. Research plans should include dose-response relationships and the description of therapeutic windows. Dependent variables must include at least behavioral or electrophysiological thresholds and anatomical measurements. If behavioral thresholds are not employed, evidence must be submitted demonstrating a high degree of similarity/correlation between the dependent measure and behavioral thresholds. At the end of the Phase I period, institutional scientific and animal use approvals must have been obtained and submitted for approval by the appropriate regulatory bodies of the U.S. Army Medical Research and Materiel Command.

PHASE II: Description of dose-response relationship comparison between at least two micronutrients and the dependent measures. The format of data reporting must be coordinated with Army subject matter experts to permit convenient comparisons between and among agents.

PHASE III: Results of Phase I and Phase II efforts will identify the most efficacious micronutrients for use in prevention and treatment of noise-induced hearing loss. Following that identification, human clinical trials may begin for eventual FDA approval. Identification of the role of micronutrients in reducing susceptibility to noise-induced hearing loss will permit the promulgation of nutritional requirements and recommendations to reduce the prevalence of hearing loss in industry and the military. Nutritional supplements currently are being marketed supporting "good hearing health." There clear is a commercial and military market for food products or dietary supplements that reduce potential for noise-induced hearing loss.

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KEYWORDS: noise-induced hearing loss, drug, micronutrients, protection, treatment

A06-163 TITLE: <u>Robotic Force Health Protection from Chem-Bio Agents and IEDs</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Design and prototype an inexpensive compact, field portable, stand-off high-efficiency, rugged, integrated detection and identification system for chemical & biowarfare agents; industrial toxic gases, and chemical components of Improvised Explosive Devices (IEDs) and integrate it with one of the emerging family of Future Combat Sysetms (FCS) and Joint Robotics Program (JRP) unmanned ground vehicles (UGVs) intended for medical force health protection and combat casualty care and diagnosis.

DESCRIPTION: The real-time detection and identification of bio and chemical warfare agents as well as potential toxic industrial gases and Improvised Explosive Devices (IEDs) is of paramount importance for protecting military medical first responders and their patients on the battlefield and for counter-terrorism response at home. Several efforts are underway to leverage the emerging Army Future Combat System (FCS), Department of Defense (DOD) Joint Robotics Program (JRP), and PM Force Protection Family of Rapid Response Equipment (FIRRE) Joint Architecture for Unmanned Systems (JAUS) compliant Unmannded Ground Vehicles (UGVs) for a variety of force protection missions including casualty location, assessment, protection and evacuation. Several of these UGV robots have been equipped with the Army Chemical School chemical and radiation detection package known as CHARS by the Navy Space & Naval Warfare Systems Center (SPAWAR) and subsequently tested with troops in the field to include combat operations in Iraq. The Chemical weapons HAzardous gas & Radition Sensor (CHARS) package includes three standard sensors: the MultiRAE hazmat environmental gas sensor, the Joint Chemical Agent Detector (JCAD) nerve, blister and blood agent sensor, and the AN/URD Radiac 13 gamma and neutron radiation detector. CHARS has been implemented with JAUS on several medical combat casualty location and evacuation robots so that potential chemical and radiation contamination can be detected by the robots prior to and simultaneously with casualty location, assessment and extraction. However, just as important to medical first responders is knowledge of the presence and potential exposure of casualties to biowarfare agents, toxic industrial gases and IEDs. No mobile robotic capability to detect and identify biowarfare agents in the field currently exists and no integrated capability exists that will enable detection of both chemical and bio-agents as well as industrial toxic gases and IEDs. Such a capability would enable combat medics and other first responders to monitor and detect multiple threat agents without risky exposure as well as aid in diagnosis. Several approaches to chemical agent detection have been attempted. Since most chemical and nerve warfare agents have extremely low lethal dosages and short reaction times, countermeasures require a detection system to: 1) rapidly respond to an incoming threat; 2) accurately determine the threat level with a minimal false alarm rate; 3) be low-cost, rugged, portable, and suitable for field operation. The system should be light enough to be carried by a single soldier or small robot; 4) be multiplexible such that multiple sensor heads should be connectable via wire or wireless to a sensing network. Since most of chemical warfare agents have short reaction times, an effective system should have a short reaction time (<1 second). To minimize the false alarm rate, the system must be able to detect multiple signature lines of warfare agents simultaneously with no significant added costs. Optical remote sensing is regarded as one of the best sensing technologies to detect trace chemicals in atmosphere and water. However, optical technology often suffers from high component and operational costs (i.e., tunable lasers) and is difficult to employ in dirty environments where visibility and light transmission is impaired. Recent advances in the fiber optical industry have led to a significant cost reduction in optical components and systems (Ref 15), making possible a new generation of inexpensive optical systems for high-sensitivity chemical sensing. Likewise, Raman spectroscopy has been recognized as an extremely useful method for chemical and gas sensing. However, the Raman cross-section for most chemical warfare agents is small. This leads to weak Raman signal, low detection sensitivity, long signal accumulation times, and requires high-power lasers with large power consumption. Recently, it has been demonstrated that Raman signals can be enhanced dramatically by using nanotechnology. Advances in last few years in the fiber optics industry have also made possible a low-cost and inexpensive laser to perform highly-efficient Raman spectroscopy. The sensitivity of the Raman spectroscopy could also be enhanced dramatically by using nanotechnology and therefore consume much less power than traditional Raman systems (Refs 16-18). As with chemical agents several previous approaches to field detection of bioagents include: light based fluorescence polarization (Ref 1), nanotechnology (Refs 2, 3, 14,) fiber optics (Ref 3, 4) biological recognition based on bacteriophage displayed peptide receptors (Ref 4), and fluorometric and light scatter spectra (Ref 5). While the technologies employed by these techniques are robust, the problem with current detectors is that in order to collect and process the samples, the first responder medic operators are potentially exposed to contamination or infection themselves. In addition to the agent detection and identification approach itself, other Research questions that need to be addressed include: 1) prototype design or adaptation of robotic manipulator(s) for collecting samples from air, water, soil, personnel, and exposed equipment; 2) miniaturization of prototype robotic sample collector and assay device(s) sufficient to be mounted on a small (<80 pound) UGV; 3) prototype design and implementation of sampling and assay application software via onboard and/or remote processors; 4) integration and implementation of JAUS compliant, command and control of the robotic environmental sampling tool and assay device on the base UGV communication system. JAUS is required to enable operation of the robotic sampling and assay device from any of the FCS or JRP UGV controllers.

PHASE I: Design prototype environmental sampling and assay payloads and develop a plan to integrate them with one of the DOD Joint Robotics Program JAUS compliant tactical robots.
1) Design a prototype Joint Architecture for Unmanned Systems (JAUS) compliant robotic manipulator(s) for collecting samples from the environment (water, soil, and air) and from exposed personnel and equipment (e.g., a robotic arm that can both collect environmental samples and place the samples in the onboard assay device for analysis). 2) Design a prototype sample assay system utilizing a technology which can both significantly enhance agent detection and also be capable of being implemented on a small tactical robot (e.g., nanotechnology enhanced Raman spectroscopy, light based fluorescence polarization, fluorometric and light scatter spectra, etc.) demonstrate dramatic enhancement of detection sensitivity, accuracy, and short reaction time (<1 second) for an integrated approach to detection and identification of militarily significant chemical and bioagents, industrial toxic gases, and Improvised Explosive Devices (IEDs) (based on relevant chemical signatures). Instantiate the design for at least one potential chemical (e.g. Sarin) and one biological agent (e.g., anthrax) and one common IED component (e.g., TNT). 3) Formulate strategy and develop a plan for integration of the assay device(s) and environmental sampling tool(s)with Joint Architecture for Unmanned Systems (JAUS) Compliant communications and computer processing systems onboard a prototypical Future Combat Systems (FSC) Small Unmanned Ground Vehicle (SUGV) (e.g., Packbot, Talon, Wolverine).

PHASE II: 1) Develop and demonstrate a prototype system with dramatic advancement in sensitivity, accuracy, and short reaction time (<1 second) for an integrated approach to detection and identification of militarily significant chemical and bioagents, toxic industrial gases and Improvised Explosive Devices (IEDs). Implement the design for multiple potential agents from each of the four groups: chemical, biological, industrial, and common IED components.
2) Develop and demonstrate Joint Architecture for Unmanned Systems (JAUS) compliant robotic manipulator(s) for collecting and processing samples from the environment (water, soil, and air) and from exposed personnel and equipment.
3) Integrate and demonstrate the environmental sampling tool(s) and assay device(s) with communication and computer processing systems onboard a typical Future Combat Systems (FCS), Joint Robotics Program (JRP), or Family of Rapid Response Equipment (FIRRE) combat casualty care Unmannded Ground Vehicles (UGVs).

PHASE III DUAL USE APPLICATIONS: 1) Collaborate with topic author in transitioning the prototype system to operational testing under the Future Combat System (FCS), PM Force Protection Force Protection Family of Rapid Response Equipment (FIRRE) Integrated Product Team (IPT), Department of Defense (DOD) Joint Robotics Program (JRP), the Personnel Recovery, Extraction, Survivability/Smart-Sensors (PRESS) or the Chemical, Biological, Radiological, and Nuclear (CBRN) Unmanned Ground Reconnaissance (CUGR) Advanced Concepts Technology Demonstrations (ACTD)
2) Transition the system to dual use casualty rescue applications with civilian police, fire, and medical first responders through ongoing US Army Medical Research and Materiel Command (USAMRMC) Telemedicine and Advanced Technology Research Center (TATRC) administered civilian first responder programs. Candidate dual-use civilian emergency first responder programs include the Center of Excellence for Remote and Medically Underserved Areas (CERMUSA) Robotic Emergency Medicine & Danger - Detection (REMED-D) program, the National Bioterrorism Civilian Medical Response Center (CiMeRC), and the Texas Training and Technology for Trauma and Training (T5) program.

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KEYWORDS: robot; bioagent; chemical; toxic gas; IED detection; medical evacuation; combat casualty care; JAUS; bio assay; Chemical Biological warfare agents; Toxic Gases; Improvised Explosive Device; Raman spectroscopy; Sensors; Optics

A06-164 TITLE: Dynamic Contrast Enhancing - Magnetic Resonance Imaging Agents for Angiogenesis Detection

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop dynamic contrast enhancing - magnetic resonance imaging agents and methods for angiogenesis detection.

DESCRIPTION: The intent of this topic is to develop dynamic contrast enhancing-magnetic resonance imaging ((DCE–MRI))-based methods for detecting angiogenesis. Coupling dynamic contrast enhancing agents to MRI has the potential to provide in vivo, functional assays of physiological processes such as angiogenesis. Angiogenesis is intimately associated with both wound repair and advanced stages of cancer. Dynamic contrast enhancing-MRI agents have promise to facilitate MRI-based monitoring of angiogenesis. DCE-MRI agents could provide better monitoring/treatment of battlefield injuries to improve the survivability of injured soldiers. In animal studies, angiogenic processes were recently implicated as part of the repair process for spinal cord injuries. Tracking these repair processes could potentially improve the clinical outcomes with these types of injuries. In addition, these agents may be utilized to monitor the progression of diseases such as prostate or ovarian cancers. Both diseases are leading sources of cancer deaths in men and women, respectively.

This topic specifically seeks to develop DCE–MRI agents and methods for MRI-based functional assays of angiogenesis/vascularization in patients with (1) surgical wounds, battlefield injuries or (2) cancers. Research directed in response to this topic solicitation should be focused on either (1) the application of DCE-MRI agents to study the complex processes of wound/trauma angiogenesis or (2) the detection and monitoring of potential pre-metastatic malignancies for more aggressive treatment planning. It is expected that this research will improve upon the clinical use of angiogenic stimulants/inhibitors. With respect to either research sub-topic area, much is unknown about the biological mechanisms of these angiogenic stimulants/inhibitors. Therefore, in order to investigate the biochemistry of angiogenic stimulants/inhibitors in detail, it is anticipated that DCE-MRI agents could be used to study changes in vascular structure or assay changes in capillary permeability in response to treatment with angiogenic stimulants/inhibitors.

PHASE I: Identify and outline the feasibility and applicability of DCE-MRI agents for the functional (time elapsed) monitoring of angiogenesis. The proposals should specifically consider the effects angiogenic stimulants/inhibitors on the treatment of (1) combat-related injuries or (2) prostate/ovarian cancers.

Use of human cells and tissues and/or animals requires approval by the appropriate US Army Medical Research and Materiel Command regulatory office. Phase I should include approval of appropriate regulatory documents (human or animal use) necessary to execute Phase II.

PHASE II: Develop novel dynamic contrast enhancing agents. Validate the in vivo potential of these agents in pre-clinical animal models. This phase would include initiating Phase I clinical studies for food and Drug Administration of safety and efficacy.

Establish collaborations to market successful candidate DCE-MRI agents.

PHASE III: Validate the potential of these agents in Phase II and III clinical trials with human subjects. The development of a detection and diagnostic methodology for angiogenesis and/or early detection of cancers would provide commercial potential in many clinical settings. A screening technique for angiogenesis that detects cancers early could reduce the morbidity and mortality currently associated with detection of cancers at late stages. Early detection of cancers is needed to best care for military personnel, their beneficiaries, and the public at large, and to reduce the health care costs incurred in treating and caring for these individuals. In addition, this technology has numerous other military applications having great potential to improve battlefield situational awareness of the military. These applications include treatment of burns and tissue replacement, surgical wounds and fractures, wound healing, diabetes retinopathy, inflammatory bowel disease, and the treatment of injuries.

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KEYWORDS: Dynamic contrast enhancing agents, MRI, angiogenesis, neovascularization, cancer detection, wound healing

A06-165 TITLE: <u>Micro Electronics for Intraoral Salivary Hydration Sensor</u>

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop a micro-electronic package for the basic intraoral sensor platform suitable for field deployment. This package will include a sensor small enough in size that it can be etched and bonded onto a tooth. This sensor will include a micro osmometer needed to measure the hydration level and circuitry to transmit/relay the data, first to a short range transmitter located extraorally on a Soldier and subsequently to a remote monitor 1-2 miles away. Any intraoral power supply and wiring must be compatible with ISO medical device corrosion standards.

During Phase I the proposer shall establish a design specification that is compatible with related field standards, and design and conduct proof of concept testing of an intraoral sensor capable of wireless communication. During Phase II proposer shall produce a device that meets the design specification, is practical in terms of cost and manufacturability for commercialization, and is field trailed in a realistic setting.

DESCRIPTION: A microfluidic intra-oral hydration sensor to determine a Soldier's hydration status is in the process of development. A critical component of this sensor is the requirement to have electronic capabilities to record signal and transmit data over a short range; from oral cavity to a larger transmitter located elsewhere on the Soldier. This amplified signal must be transmitted over a longer range, 1-2 miles, so a combat medic or care provider can remotely monitor a Soldier's hydration status. An electronic package, with a sufficiently small and corrosion resistant power source, for an intra-oral sensor platform must be outlined. At least one alternative candidate must also be outlined. It must be small enough to fit in the oral cavity, be non-corroding in oral fluids, the transmission range should be considered (including through human tissue), battery life, reliability, resistance to interference and ease of use must be demonstrated. The success of military operations as well as survival in combat depends upon the ability of military personnel to deal effectively with environmental conditions. Throughout military history, more deaths and injuries in war have been documented to extreme weather conditions than to battle casualties. By far the most important weather extreme to military operations is heat, because so many strategically important world areas are in hot regions, and because heat exposure can seriously impair human performance in many ways (1-4).

PHASE I: Develop and test at least two alternate proof of concept approaches to micro electronic communication between an oral cavity wireless sensor and a central unit located somewhere on the Soldier. Select most successful approach for application. Demonstrate a microelectronic package, complete with self contained power supply, can be constructed at small enough dimensions to be bonded to a tooth without interfering with normal oral functions, such as eating, speaking and drinking. This can be accomplished by designing a sensor whose dimensions fit within the normal buccal second dimensions of maxillary second molars. All materials and any batteries must meet ISO corrosion standards and any corrosion by-products must be identified and their biological actions accounted for. Artificial saliva can be used as a corrosion media. There is no need for in-vivo testing at this point. Proof of the correlation between salivary osmolality and overall hydration levels is NOT part of this SBIR. Work is currently being accomplished in-house at USADTRD to establish this relationship. Currently intraoral temperature sensors, bio/chem hazard detection and alive/dead sensors are being developed. This electronics package should/will function with each of these. Use of human subjects and human samples (i.e. saliva) would require review by the US Army Medical Research and Materiel Command regulatory office in addition to local Institutional Review Board approval. Phase I should include approval of appropriate human subject regulatory documents necessary to execute Phase II.

PHASE II: Design a prototype device that can be tested for accuracy and transmission of the data. Following the human subjects protocol approval, preliminary field testing of this device will be executed. This device should be capable of collecting data for measuring hydration levels and transmitting the data over the ranges specified.

Although designed primarily to function with an intraoral osmometer, the electronic package developed during this SBIR should be adaptable to allow power supply and transmission of data for any intraoral sensor developed. The corrosive nature of the saliva environment will not alter from application to application.

PHASE III: Soldiers operating in extreme environments; including very hot or very cold temperatures and a wide range of humidity, are always vulnerable to dehydration. Allowing far forward medical personnel to monitor hydration levels in Soldiers and to be able to interdict prior to the onset of symptoms will be a tremendous force multiplier. If successful, dehydration and heat injuries could become very rare if not completely eliminated. Any civilian profession in which dehydration is a potential problem, fire fighters, football players, HAZCOM responders would greatly benefit from continuous hydration monitoring. Although designed primarily to function with an intraoral osmometer, the electronic package developed during this SBIR should be adaptable to allow power supply and transmission of data for any intraoral sensor developed. The corrosive nature of the saliva environment will not alter from application to application. Currently intraoral temperature sensors, bio/chem hazard detection and alive/dead sensors are being developed. This electronics package should/will function with each of these.

REFERENCES:
1) Johnson, R. F.; Kobrick, J. L.; Text book of Military Medicine, Medical Aspects of Harsh Environments- Vol. 1, Chapter 4- sychological Aspects of Military Performance in Hot Environments; 2002.
2) Medical Surveillance Monthly Report March 2000; 6(3).

3) Sawka, M. N.; Pandolf, K. B.; Text book of Military Medicine, Medical Aspects of Harsh Environments- Vol. 1, Chapter 3-Physical Exercise in Hot Climates: Physiology, Performance, and Biomedical Issues; 2002.
4) Goldman, R. F.; Text book of Military Medicine, Medical Aspects of Harsh Environments- Vol. 1, Chapter 1-Introduction to Heat-Related Problems in Military Operations; 2002.

KEYWORDS: micro-Electronics, sensors, intra-oral power source, hydration monitors

A06-166 TITLE: Rapid and Early Detection of Prions

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a human, deer, elk, or beef cattle cell culture model system for prion propagation which can be used for antemortem detection of prions.

DESCRIPTION: Prion diseases, also called transmissible spongiform encephalopathies (TSEs), are a family of neurodegenerative disorders affecting both humans and animals. They are caused by the accumulation of an abnormal form of a protein known as prion that results in neuronal death and a characteristic spongiform appearance of the brain tissue. Acquired prion diseases have been linked to prion-contaminated food entering into the food chain of humans and animals, prion-contaminated surgical instruments, infected tissues and organs from prion-infected donors, and contaminated blood products.

At present there is no antemortem diagnostic for TSEs in human blood or food supplies, or animal food supplies. The origin of variant Creutzfeldt-Jakob disease (vCJD), a fatal human degenerative disease arising from exposure to prion-infected cattle, has raised concern of transmission of prion diseases from consuming elk and deer. Moreover, there is no cure, prophylaxis, or treatment for prion diseases. Thus, there is an critical and urgent need of a cell culture method that could be used to detect prion infection in the preclinical phase of the disease (antemortem).

This topic solicitation is directed toward the development of a sensitive, specific, reproducible, and rapid cell culture model system for the early detection of prion infection. The intent of the project should be to develop a simple novel cell culture system derived from human, deer, elk, or beef cattle for prion propagation. The cell culture system should be able to demonstrate infectivity prior to the onset of symptoms, and should replace the whole-animal bioassay currently used for testing TSEs infectivity.

PHASE I: Select one species, either human, deer, elk, or beef cattle for the development of cell lines. Develop a strategy for the development of cell lines that will support prion propagation at detectable levels. This strategy should include a detailed plan on 1) the tissue and types of cells that will be used, 2) access to the tissues and/or cells for the selected species, and 3) how the cells will be developed.

Collaboration/subaward with investigators that have access to and capabilities in prion research is encouraged.

Use of human cells and tissues and/or animals requires approval by the appropriate US Army Medical Research and Materiel Command regulatory office. Phase I should include approval of appropriate regulatory documents (human or animal use) necessary to execute Phase II.

PHASE II: Create novel cell lines from the selected species. Demonstrate a sensitive and specific method for detecting propagating prions in the in vitro cell culture system. Develop and validate a bioassay for detecting prions in tissues and body fluids. The bioassay must be sensitive, specific reproducible, and focused on antemortem detection.

A detailed commercialization plan for marketing the components of the cell model and detection kit should be included.

PHASE III: The commercialization potential of the resulting cell model and antemortem bioassay is high and is an important consideration for the military and civilian communities, and government, state and local agencies. The rapid antemortem prion bioassay is critical to assessing food, blood and organ donor supplies. This technology would be used to screen animals at the time of slaughter, screen live herds, screen the human blood supply, and screen organ and tissue donations. Screening of live herds and animals at the slaughterhouses can prevent the introduction of contaminated food into the food chain, and offset a potential economic diaster for the food industry. Detection of prion disease in advance of blood donations can prevent introducing infected blood into the blood supply system.

Proof of principle in Phase II should be sufficient to facilitate marketing of this bioassay to pharmaceutical or biotech companies possessing the capability of completing bioassay kit development and any required FDA approval.

REFERENCES:

1. Collinge, J. 2001, Prion diseases of humans and animals: Their causes and molecular basis 24:519-50.
2. Prusiner, SM. 1998, A Molecular pathology of prion disease. Proc Natl Acad Sci 95:13363-83.
3. Kubler E., Oesch B., and Raeber A. J., 2003, Diagnosis of prion diseases. British Medical Bulletin 66:267-279.
4.Ingrosso, L., Vetrugno, V., Cardone, F., and Pocchiari, M. 2002, Molecular diagnostics of transmissible spongiform encephalopathies. Trend in molecular Medicine 8:273-280.
5. Will, RG et al., 1996, A new variant of CJD in the UK. Lancet 347(9006): 921-925.

KEYWORDS: Prion propagation, prion diagnostics, infectivity bioassay, cell culture model, early detection of prions

A06-167 TITLE: Development and Automation of a Novel Dengue Neutralization Assay

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop a high-throughput assay for determining the presence and quantity of neutralizing anti-dengue serum antibodies appropriate for conducting immunogenicity testing in large-scale clinical trials supporting dengue vaccine licensure.

DESCRIPTION: There is urgent need in the government and private sector for the development of high-throughput assays capable of characterizing antibody responses that determine the primary immunogenicity endpoints for vaccine trials. Through the Military Infectious Diseases Research Program, the Naval Medical Research Center (NMRC) has developed a novel assay capable of determining the presence of neutralizing anti-dengue antibodies in serum with higher throughput and equivalent or greater precision than the current standard, the plaque reduction neutralization assay (PRNT). The NMRC assay is based on measurement of dengue infection by means of immunofluorescent detection of dengue antigen via flow cytometry in cells rendered susceptible to dengue infection by transfection with the dengue receptor molecule DC-SIGN (CD209). The read-out currently employed is an objective measure vice the semi-subjective visual inspection used to count plaques in the PRNT. This procedure is theoretically amenable to high-throughput processing and analysis, permitting maximum iterations of runs and assessment of multiple conditions (e.g., multiple viruses) easily. However, thus far it has been tested only in the laboratory setting and is not fully automated. Ultra-high-throughput capability would require maximal reduction of manual processing steps. Since several pathogens other than dengue are known to utilize DC-SIGN and related molecules as receptors, an antibody assay based upon this concept could be developed for a range of infectious agents and thus potentially be multiplex and therefore applicable to testing antibody responses to several vaccines ("cross-platform"). True ultra-high-throughput capability, as well as broad applicability to other infectious disease systems, could be achieved by use of additional novel cell substrates in addition to DC-SIGN-expressing cells and/or by means of non-cellular substrates such as microspheres engineered to display relevant receptor molecules, coupled with novel detection modalities leveraging existing technologies.

PHASE I: Refine an assay capable of determining the presence of neutralizing anti-dengue antibodies in serum with higher throughput and equivalent or greater precision than the currently existing FACS-based assay by maximally reducing sample handling and processing requirements to a single step, utilizing alternative infection read-outs or infection surrogates as appropriate. Demonstrate proof-of-principle of a multiplex assay for simultaneous measurement of neutralizing antibodies against multiple viruses in a single serum sample.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions in US and overseas (US military) laboratories involved in vaccine testing.

PHASE III: This system could be used in a broad range of immunologic testing applications in support of licensure of other vaccines, as well as rapid and large-scale testing of candidate antiviral pharmaceutical compounds for treatment and prevention of dengue and other virus infection.

REFERENCES:
1) Tassaneetrithep B, Burgess T, Granelli-Piperno A, Trumpfheller C, Finke J, Sun W, Eller M, Pattanapanyasat K, Sarasombath S, Birx D, Steinman R, Schlesinger S, Marovich M. DC-SIGN (CD209) mediates dengue virus infection of human dendritic cells. The Journal of Experimental Medicine, 2003 April 7; 197(7):823-9.

2) Martin NC, Pardo J, Simmons M, Tjaden JA, Widjaja S, Marovich MA, Sun W, Porter KR, Burgess TH. An immunocytometric assay based on dengue infection via DC-SIGN permits rapid measurement of anti-dengue neutralizing antibodies. Journal of Virological Methods. 2006 Jan 14; [Epub ahead of print]

KEYWORDS: dengue, virus, neutralization, antibody, high-throughput, automation

A06-168 TITLE: <u>Wireless Sensor Network with Multiple Sensors for Chemical and Biological Threat Detection</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop a flexible, wireless sensor network (WSN) with smart decision making capabilities for the real-time rapid detection of chemical warfare agents, toxic industrial chemicals, and biological threats. Nodes within the network should pre-process (and condense) data before transmitting it to a collection location. The “sensor layer” of the network architecture should be detached from the “network layer” so that sensors can be easily inter-changed, depending on the need.

DESCRIPTION: Rapid and early detection of chemical and biological agents will depend on deploying efficient and effective wireless mesh networks and sensors. Each “node” (sensor and radio) within the network should have a 1) sensing capability, 2) unique identifier, 3) on-board processing power, and 4) ability to perform multiple roles, and 5) ability to operate collaboratively in a mesh network.

Determination and definitive analysis of chemical/biological threats will depend on fusing large amounts of data from multiple sensors, like sensor concentration data, timestamps, and location. Only by integrating this data can an accurate picture of the environment be drawn. Unfortunately, current wireless sensor networks have not yet exploited the full advantage of available wireless technology. They often operate as if they are linked with “invisible wires” and only use their wireless capabilities to send sensor data. However, advances in miniaturization and manufacturing of nodes (both radio chips and sensors) are enabling a dramatic evolution in intelligent wireless networks. Not only can the nodes collect and transmit data wirelessly – but they’re now capable of performing analyses, Multi-Sensor Data Fusion (MSDF), and making smart decisions -- right on the nodes – before the data is transmitted. This can significantly increase the operation and output of wireless sensor networks: 1) By performing analysis/decisions on the node, the amount of data transmitted to the central station can be greatly reduced. 2) Reduced transmission time means less air time and chances for transmission errors. 3) Since the task of transmission is a “battery hog” significant battery life is conserved when transmission tasks are reduced. 4) When all the data is transmitted, it limits the practical size number of nodes that can operate in a network; however, when on-board processing is performed on the nodes, the size of the network can grow exponentially. Thus, each node should have on-board processing power and the ability to collaborate efficiently with each other, whether in a network of 10 nodes or a network of hundreds of nodes.

Additionally, each node should also be able to auto-configure and perform any of the required network functions within the environment. They should be able to operate collaboratively to communicate data without any pre-planned infrastructure – so that nodes can be sprinkled where needed without stipulating where each routing or collecting node must be positioned. The nodes should use micro-electro-mechanical (MEMS)-based technologies to reduce the packaging size so that they are small enough to be covertly deployed and concealed within the target environment. And each node should be self sufficient by having its own power supply.

Advances in node electronics are also allowing new views on WSNs by separating the “sensor layer” from the “network layer.” Currently, most RF transmission components are tightly integrated with the sensors by both hardware and software. However, by separating the layers, it allows much greater flexibility in selecting only the specific sensors that are needed.

Other node and network requirements include the following. The data transmission range needs to be from a few hundred feet to a mile. Innovative architectures to extend the range of wireless sensors are encouraged. Technology approaches to reduce transmission overhead and conserve battery life is encouraged. The network should be capable of being unmanned for at least one month at a time and should include self-monitoring and self-healing capabilities, The self contained network power must last for at least one month. The transmission rate of the nodes will vary with the types of sensors and the data being collected. Thus, the network will have to accommodate varying message rates, from a few per second to hundreds per hour, depending on the chemical/biological threat to be detected. The proposed network must accommodate this wide range of data transmission requirements with maximum efficiency. The architecture will be flexible so that it can be used in a range of military and civilian applications. To make that feasible, the cost should be low so that it is affordable for deployment.

PHASE I: Perform an assessment and design the architecture of a smart and flexible wireless sensor network (WSN) with on-board processing. Using currently available sensors and RF components, demonstrate the real-time communications, on-board processing (limited processing in Phase I), and mesh networking capabilities of a small, prototype WSN for detecting chemical/biological threats (using off the shelf chemical/biological sensors, eg, silicon inferometer sensor detecting hydrogen fluoride from nerve agents, developed by Univ. of California, San Diego, Pacholski et al, 2005). Phase I options could include: a) integration of more on-board processing tasks, including Multi Sensor Data Fusion; and b) development of flexible and resilient physical packaging for differing deployment strategies.

PHASE II: Demonstrate the deployment of a larger WSN with 25+ nodes and more advanced on-board processing techniques, including MSDF and collaboration on and between the nodes in the network. Develop statistical methods and tools for geo/environmental informatic surveillance of anomalies, aberrations, elevated clusters or critical areas for early warning and detection. Develop numerous scenarios for deployment in both a military and civilian application.

PHASE III DUAL USE APPLICATIONS: Transition the technology developed in this topic to real life applications for both military and civilian benefit, like real-time monitoring of chemical and biological threats in mass transit, pre-monitoring of potential battlefields, remote monitoring of injured soldiers or civilians and patients with chronic medical conditions for transition to independent living at home.

REFERENCES:
1. Pacholski C, Sartor M, Sailor MJ, Cunin F, Miskelly GM (2005)
Biosensing using porous silicon double-layer interferometers: reflective interferometric Fourier transform spectroscopy. J Am Chem Soc. 2005 Aug 24;127(33):11636-45.

KEYWORDS: chembio detection, sensors, wireless networking, chemical warfare agents, Biological warfare agents, multisensor data fusion techniques

A06-169 TITLE: High Performance Lightweight Transparent Armor Materials

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop lightweight transparent armor materials that have ballistic impact resistance comparable to state of the art fiber reinforced polymer composite armor. The overall goal is to substantially increase the level of eye and face ballistic protection available to Soldiers, without increasing equipment weight.

DESCRIPTION: Polycarbonate (PC) and polymethylmethacrylate (PMMA) have been the standard for lightweight transparent ballistic protection materials for decades. There have been many projects carried out in government, industrial and academic laboratories to produce lightweight transparent materials with improved ballistic performance, most focusing on the design and synthesis of new transparent polymers. There has been some incremental progress in this area, but PC and PMMA/PC hybrids remain the most widely used lightweight transparent materials for ballistic protection in applications such as eyewear and face shields for personnel protection. There is a substantial performance gap in the ballistic impact resistance of monolithic polymer transparent materials such as polycarbonate [1], and that of state of the art fiber reinforced polymer composites (FRCs) such as Spectra Shield® [2]. Even though both material systems are 100% organic polymer compositions, the ballistic protection efficiency (on a weight basis) of the FRC materials is typically much greater than that of monolithic transparent polymers. The primary reason for this is the very high tensile strength of the fibers in the FRC materials that is lacking in polycarbonate or other isotropic lightweight transparent materials. This strength derives from the high degree of polymer chain orientation in the fibers. However, currently available FRC armor materials are typically opaque, or at most translucent, which precludes their use in protection applications such as goggles or face shields. As a result, the level of protection available for Soldiers’ faces is considerably less than that provided by the helmet used to cover the rest of the head. In order to close the performance gap between currently fielded lightweight armor transparencies and FRCs, it is desired to create a transparent polymeric material or composite with highly oriented polymer chains, either by producing a transparent fiber reinforced composite with a high degree of fiber loading, comparable in structure to currently used FRC armor materials, or a transparent material in which the polymer chains are highly aligned throughout the body of the material to create a high tensile strength transparent lens. Work has been previously reported [3] on making unidirectional oriented polypropylene films and laminating these films in a 0o/90o cross-plied lay up to create a transparent lens material with ballistic impact resistance significantly higher than monolithic polycarbonate, but less than modern FRC armor materials. This material was not fully commercialized, possibly due to manufacturing challenges encountered at the time. Significant changes in materials science and technology have taken place in the 25 years since the cited work was performed that could improve the viability of an updated approach to this problem. Commercial polymer quality and availability has improved, process equipment control has improved, and understanding of polymer structure-property relationships has advanced considerably. There is also greater demand than ever for lightweight impact resistant transparent materials. The overall objective of this project is to produce new lightweight transparent polymers or composites that have ballistic protection efficiency comparable to state of the art fiber-reinforced polymer matrix composite armor materials and simultaneously have optical properties comparable to commercial polycarbonate eyewear. Potential approaches include, but are not limited to, transparent fiber reinforced polymer composites, highly oriented polymer film laminates, or other approaches that incorporate a high volume fraction of high tensile strength component into a lightweight transparent material system. In the interest of keeping ultimate product costs low, it may be most effective to utilize commercially available materials as the basis of any proposed approach. Understanding and systematically addressing the properties of materials that affect the transmission of visible light through materials is critical to the success of any proposed approach.

PHASE I: Conceive and demonstrate innovative technology to create optically transparent (visible spectrum) lightweight materials having ballistic protection efficiency at least 50% greater than what is required for currently fielded polycarbonate protective eyewear or face shields, and optical properties comparable to commercial polycarbonate eyewear or face shields [4, 5]. Identify a viable pathway to rapid scale up and transition of the material technology to commercial production.

PHASE II: Develop the processing techniques and material systems identified in Phase I. Optimize process parameters and scale up the process to demonstrate the ability to produce a product using methods viable for commercial production, while maintaining consistent quality. Demonstrate the ability to produce acceptable finished parts for military applications such as goggle lenses or face shields that demonstrate 50% or greater improvement in ballistic efficiency over commercially available items while meeting or exceeding all applicable specifications for the target end items [see 4, 5].

PHASE III: Impact-resistant lightweight transparent materials are in high demand for use in a wide variety of military and civilian applications. Examples include protective eyewear and face shields for the military, first responders (police/fire) and industrial safety applications, ground vehicle and aircraft windows, and lightweight safety glazing.

REFERENCES:
1) Wright S. C., Fleck N. A. and Stronge W. J., 1993: Ballistic Impact of Polycarbonate – An Experimental Investigation, Int. J. Impact Engineering, 13[1], p1-20.
2) Honeywell Spectra Shield® web site: http://www.honeywell.com/sites/sm/afc/spectra_shield.htm
3) Transparent Polyolefin Film Armor (August 1981). Ralph Shelton, Final Report Contract No. DAAG46-76-C-0034. AMMRC Technical Report TR 81-41. Available from DTIC (http://stinet.dtic.mil/) AD no. ADA107562.
4) Commercial Item Description (CID) for transparent face shield: http://assist.daps.dla.mil/docimages/0001/94/72/A-A-5954.PD2
5) Commercial Item Description (CID) for eyewear: http://assist.daps.dla.mil/docimages/0000/45/51/109750.PD0

KEYWORDS: transparent armor, polymers, films, fibers, high strength, eyewear, face shield, goggle

A06-170 TITLE: <u>Development of Extruded Self Mating Closure System</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To create a technically superior low cost extruded self-mating closure tape system that allows for single handed action engagement, same as current woven hook and loop, i.e., through slight pushing engagement action and single handed pulling disengagement action, but yet; provides for anti-peel non-fraying cold cut edges, flame resistance, stealth i.e., 80% noise reduction, permanent colorfastness, laundering resistance and long life durability.

DESCRIPTION: Commercial Item Description A-A-55126, ‘Hook and Loop, Closure Tape System’ is based upon traditional woven textile technology construction that lends itself to field failure during laundering. During field laundering loop tapes can fray or peel along the edges after two or three cycles. During laundering/drying the hook tape engages with the loop tape in a constant manner while tumbling in a wet state. What worsens the situation is that the wet state end-item garments possess added mass that intensifies the engagement and disengagement process. This added weight hastens the abrasion process and causes premature field failure, especially for items such as the Army Combat Uniform (ACU). Another situation is that current extruded hook is unforgiving in its engagement and disengagement force when mated with its traditional textile based loop tape, thus actions may peel out all the loop material over an extended period of time or shorten its field life. An ideal balance would be to create a new family of extruded hook and loop single touch self mating closure system offering long term durability, infinite width ranging from 5/8 – 4 inch without fraying or peeling, permanent color fastness, flame resistance, heat resistance i.e., to touch of hot setting electric clothes iron, Ultraviolet (UV) resistance, anti-lint/dirt/mud pickup and stealth or silence while maintaining A-A-5516, Type II, Class I physical peel and shear properties and capability to provide for either manual or automated sewing processing without breaking needles or thread.

PHASE I: To demonstrate the feasibility of using alternative extrusion/polymer technologies or fabrications/assemblies other than current weaving/knitting manufacturing processes for enhancing the technical performance of typical flat hook and loop tape closure system. Loop tape shall engage with typical extruded or alternate extruded flat hook tape used for hook and loop closure systems on pocket flaps, cuff adjusters, badge and name tape retainers, zipper flaps or other typical clothing/outdoor applications. Tape system shall be soft, supple, non-irritating, sewable, flame resistant, possess silent disengagement, i.e., offer min of 80% noise reduction when compared to std Hook and Loop, UV light resistant, offer single hand engagement/disengagement and when sewn upon standard ACU shirt shall offer minimum of 25 launderings per AATCC Test Method 150, Permanent Press (PP) setting @ 140 F wash and 80 F rinse with 10 min agitation time and dried on PP for 45 min. Total 25 launderings required for three ACU shirts with 4 lb ballast load with 50 engagement/disengagement cycles conducted between each cycle.Technical Bi-monthly and final report required.

PHASE II: Produce a non-flame resistance prototype tape from down-selected materials identified in Phase I to conduct developmental testing and fabricate ACU end-items using designated loop tape. Material properties should be verified on prototypes before finalizing and producing semi-commercial items. Manufacturing issues will be documented to include design, production, slitting and finishing processes. Develop a non-Nomex flame resistant loop tape for field evaluation. Closure should able to be ironed with no melting or deformation. Fabricate ACU end-items using designated loop tape. Conduct developmental testing and document the research and results in a technical report with conclusions on the utility of hook and loop structures for various military applications.

PHASE III: The high-performance, extruded loop tape shall have numerous applications for both military and civilian clothing markets.

REFERENCES:
1) AATCC - American Association Textile Chemists and Colorists. (call (508) 233-4185 to request copies).
2) A-A-55126 – Woven Hook and Loop Closure Tape. (call (508) 233-4185 to request copies).
3) ACU- Army Combat Uniform. (call (508) 233-4185 to request copies).

KEYWORDS: hook and loop, closure, extrusion, polymer, flame resistant, Nomex®

A06-171 TITLE: High-Strength Low-Cost Polymer Fibers for Protective Clothing and Equipment, Shelters and Airdrop Equipment

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop and apply novel processing techniques to commodity polymers or commodity fibers to produce fibers with tensile strength comparable to current commercial high strength fibers (> 20 grams/denier), but at significantly lower cost (< $10/pound). The ultimate objective is to improve the availability of high performance fiber for a wide range of military applications, including light armor, clothing, shelters and airdrop systems.

DESCRIPTION: High strength polymer fibers are a critical component of lightweight personnel armor material systems, and of other military systems such as inflatable beams for shelters (airbeams), shelter fabrics and cordage. Products such as Kevlar®, Spectra®, Twaron®, Zylon®, and Dyneema® are all examples of commercial high strength fiber materials. These fibers are widely used in personnel armor components including vests, small arms protective insert plates, and helmets. The commercially available high strength fibers are relatively expensive, and are produced in much smaller quantities than more conventional commodity fiber materials such as polyamide, polyester or polyolefin fibers. The commodity fibers typically have mechanical properties (tensile strength, tensile modulus) an order of magnitude lower than the high performance fibers.   In recent years, many new commercial polymer grades have been introduced to the market. These new materials are a result of the development of new catalysts and polymerization processes that offer improved control over polymer structure and allow polymers to be produced that optimize a narrow range of properties for specific applications. At the same time, new additives and processing techniques have been demonstrated that allow further control over the properties of finished polymer products, including fibers. The theoretical strength of many commodity polymer fibers is considerably higher than the strength of the product that is typically produced, and these potential properties may be accessible via innovative processing methods. For example, a recent study demonstrated that a modified fiber spinning process for polyamide 6,6 (i.e. Nylon® 6,6) was able to increase both the tensile strength and tensile modulus by a factor of 10 relative to typical commercial fiber properties [1]. The objective of this project is to develop and apply novel processing techniques to commodity polymers or commodity fibers to produce fibers with tensile strength comparable to currently available commercial high strength fibers (> 20 grams/denier tensile strength), but at significantly lower cost (< $10/pound). Potential approaches include, but are not limited to, innovative fiber process equipment design, materials selection, use of process additives, design of process conditions, polymer blending or otherwise combining materials (i.e. multi-component fibers), secondary processing of ready-made commercial fiber and/or combinations of these or other approaches.

PHASE I: Demonstrate innovative technology to create continuous polymer fibers with high tensile strength (> 15 grams/denier minimum, preferably > 20 grams/denier) using commercially available commodity polymers or commodity fibers as a starting material. Identify a viable pathway to rapid scale up and transition of the technology to commercial production.

PHASE II: Develop the processing techniques and material systems identified in Phase I. Optimize process parameters and scale up the process to demonstrate the ability to produce multi-pound quantities of fiber at rates comparable to commodity fiber or yarn production processes (> 500 m/min) with consistent quality. Address issues of environmental durability, etc., needed for commercial viability of the product. These include thermal stability, UV stability, launderability, abrasion resistance and resistance to common household and industrial chemicals (i.e. fuels, oils, lubricants, cleaning products). Demonstrate the ability to scale up the process to commercial production, meeting fiber tensile strength and cost goals of 20 grams/denier tensile strength and $10/pound.

PHASE III: High tensile strength fibers are in great demand for use in a wide variety of military and civilian applications. Examples include fiber reinforced composites for armor and structural applications, soft shelters, airbeams, inflatable boats, specialty textile applications (parachutes, sail cloth) and ropes. There is a worldwide shortage of high performance fiber. A low priced high tensile strength, high modulus fiber should have excellent commercial potential.

REFERENCES:
1. High modulus Nylon 66 fibers through Lewis acid-base complexation to control hydrogen bonding and enhance drawing behavior. Jung, Dong-Wook; Kotek, R.; Vasanthan, N.; Tonelli, A. E.. PMSE Preprints (2004), 91 354-355. CODEN: PPMRA9 ISSN: 1550-6703.
2. Novel Polymeric Materials with Superior Mechanical Properties via Ionic Interactions. Hara, Masanori; Available from DTIC (http://www.stinet.dtic.mil/)
AD Number: ADA379123 Report Date: 19 FEB 2000, 8 pages.
3. "Production and Properties of High-modulus-High-tenacity Polypropylene Filaments" S. Mukhopadhyay, D.L. Deopura and R. Alagirusamy, Journal of Industrial Textiles, Vol. 33, No. 4 (2004) pp. 245-268.

KEYWORDS: polymers, fibers, high strength, processing

A06-172 TITLE: <u>Novel Textile Constructions for Puncture Resistant Inflatable Composites</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Investigate alternative fibers, hybrids, orientations, coatings and films that provide improved puncture resistance to a wide variety of inflatable structures and develop a novel fabric with minimum thickness and weight, which provides a 30% improvement in resistance to punctures, cuts and tears.

DESCRIPTION: Inflatable textiles are used by the military and in commercial industry in a wide range of products ranging from inflatable soft wall shelters to inflatable rafts and boats. A highly puncture resistant textile would improve the durability of inflatable structures used by the Army such as shelters that utilize inflatable airbeams for structural support, and across the joint forces in items such as Navy marine fenders and in various commercial applications such as inflatable rafts, tubes and flooring. Inflatable shelters fielded by the Army rely upon the strength of these textile fabrics to make up the supporting structures. Punctures, tears and cuts to these inflatable supports could lead to failure of the structure. These structures are potentially impacted by sharp or jagged objects and rocks found in the ground during set-up and installation. Damage to inflatable boat and fender technologies could potentially be caused by hazards such as sharp protruding objects found on piers and ships. Having a highly puncture resistant textile that can withstand a wide range of punctures, cuts and tears from these potentially damaging impacts is required to meet operational performance requirements.

There has been an increasing demand for structures using inflatable composite textile structures in the Army and across the Joint Forces because of their quick deployability, light weight and low bulk which allows them to be stored in a small volume compared with metal/solid structures. This inflatable technology is quickly becoming popular in other applications such as life rafts and fenders for the Navy and a wide range of commercial applications which include flooring, bedding, inflatable antennae and inflatable rafts and boats. Thus it is desirable to have a fabric that has the ability to withstand puncture in a range of environments and applications.

How easily a fabric is punctured varies greatly with the shape of the instrument being used; for example, puncture by conical tip or cylindrical tip. Ideally an inflatable textile should be able to withstand typically encountered forms of puncture without sacrificing flexibility and other physical properties and resistances. The material solution should provide improved puncture resistance to a wide variety of inflatable structures including military shelters, and inflatable ship fenders. The fabric should be as thin and lightweight as possible to maximize flexibility while offering at least a 30% improvement in resistance to punctures, cuts and tears when compared with traditional inflatable materials.

In order for the textile solution to demonstrate improved puncture resistance, the fabric must have excellent puncture resistance tested per European mechanical test EN388 using a 4.5 mm puncture probe. For comparison purposes the textile solution should also demonstrate excellent puncture resistance per ASTM F1342-91. The fabric should withstand at a minimum a 150 N puncture force (33.72lbf) tested per EN388. For improved cut resistance the selected fabric should show cut resistance of at least 6 N (1.349lbf) per ASTM F1790-04, although a higher cut resistance is desirable. With the potential for severe abrasion caused by dragging and rubbing against rough and uneven surfaces, it is also desired the fabric demonstrate minimal mass loss per ASTM D 3389. The fabric should demonstrate no more than 4 mg loss per cycle tested to this method using H-18 wheels. For woven solutions, it is also desirable that the fabric show excellent abrasion resistance in tension (at least 3lbs), showing no holes or breaks in the fabric after 150,000 double rubs with cotton duck per ASTM D 4157.

In addition to these objectives, the textile solution should maintain properties of existing inflatable textiles used by the Army. The puncture resistant fabric solution should demonstrate low flex fatigue tested per Federal Standard 191, Test Method 5102. The objective for flex fatigue is less than a 10% loss in tenacity after 100 cycles. The fabric should also weigh less than 20 oz/yd; have a tensile strength of 70 lbs tested per ASTM 885 and meet safety flame requirements per ASTM D 6413-99, with a char length of less than six inches and no flaming melt drip.

PHASE I: The first phase of the program should focus on looking at the feasibility of developing a lightweight, flexible puncture and cut resistant inflatable textile for use in airbeams and similar inflatable structures. The focus for this phase will be on researching potential material candidates, down selecting and working with the most promising candidate or candidate manufacturers for further testing and evaluation. A trade off analysis should be completed comparing the most promising puncture resistant textile technologies. The inflatable textile(s) should meet the minimum requirements for existing inflatable textiles used by the Army in areas of strength, durability, flexibility and flex fatigue. Primary focus should be on improving puncture resistance of the inflatable textile with secondary requirements for improving resistances to cuts and tears. The selected inflatable textile should also be flexible and lightweight while minimizing material and manufacturing cost. This topic is open to both coated and non-coated fabrics. Technology Readiness Level 3 (TRL 3) should be reached by the end the first phase. To achieve TRL 3, analytical and critical function and/or characteristic proof of concept must be shown.

PHASE II: The material candidates selected from the first phase should be further developed, tested and evaluated in Phase II. The most promising textile solutions should then be further down selected to the most promising puncture resistant fabric. Prototype inflatable structures, such as an inflatable beams or fenders should be developed using the most promising puncture resistant textile, demonstrating the puncture resistant technology. During this phase the most promising fabric(s) should be tested for physical properties and a prototype inflatable cylindrical composite structure should be developed approximately 8 feet in length and 2 feet in diameter. The inflatable composite should be able to withstand working pressures of 10 psi and a burst pressure of 25 psi. The prototype will be evaluated on its physical properties, puncture and cut resistances, environmental resistance, weight, cube and cost. Manufacturing techniques and methods should be optimized. The technology should be at a TRL 5 by the end of this phase. To achieve TRL 5, breadboard and/or component validation in a relevant environment must be demonstrated.

PHASE III: The inflatable textile developed in the first two phases could be integrated into existing army inflatable systems, such as airbeam and inflatable shelters, navy fenders and other structures and applications using inflatable composite technology. Commercial uses of the fabric would depend on the type of product or products that are selected for development. This technology could potentially be used in a wide variety of applications ranging from inflatable boat technology, flooring, shelters, fenders and bedding. Improvements in the puncture resistance of inflatable textiles would provide increased protection and usability for a broad range of inflatable applications.

REFERENCES:
1) www.astm.org ASTM F1790-97, Standard Test Method for Cut Resistance of materials used in protective clothing.
2) www.astm.org ASTM F1342-91, Standard Test Method for Protective Clothing Material Resistance to Puncture, ASTM International, June 1996.
3) http://usainfo.com, MIL STD 3030, Puncture Resistance of Packaging Materials (reference can also be obtained by calling 508-233-4591).
4) http://www.military.com/soldiertech/0,14632,Soldiertech_Air,,00.html?ESRC=soldiertech.nl
5) http://journalsip.astm.org/JOURNALS/JAI/PAGES/203.htm , A Study on Puncture Resistance of Rubber Materials Used in Protective Clothing, 4 April 2005.
6) http://www.warwickmills.com Test Protocol for Compartive Evaluation of Protective Gloves for Law Enforcement and Corrections Applications, NIJ Protocol 99-114, June 1999.
7) http://www.vectranfiber.com

KEYWORDS: Inflatable, Textiles, Puncture, Resistance, Lightweight, Air Beams, Fabric, Fiber

A06-173 TITLE: Battlefield-Fuel Transpiration Membrane

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a high-temperature, oleophobic transpiration membrane that will promote vaporization of the battlefield fuel, JP-8. The membrane will be used in a device that mixes air with fuel vapor and flamelessly combusts the mixture.

DESCRIPTION: Soldiers require significant amounts of energy to heat water and food, charge electronic communication and GPS devices, and for cooling and heating inside special protective clothing. Heat for water and food is currently provided by cumbersome, low-tech, low-efficiency camp-stoves(1), and chemical heaters which have limited output and application. Electricity is supplied by costly, bulky, heavy batteries, which when depleted are hazardous waste.

Multiple forms of energy for these applications are best provided by devices powered by battlefield fuels. Such devices will reduce the equipment weight and bulk Warfighters must carry, and re-supplying fuel is easier than batteries. But development of stoves, heaters, chillers and personal electric generators (e.g., fuel-cell or thermoelectric) small enough to be carried by the individual Soldier, and which are effective, economic and practical, has been hindered by the difficulty of vaporizing heavy fuels at low rates and with no electrical power. This is because these fuels are viscous, lack volatility, and are a mixture of several distillates which tend to separate during the vaporization process.

Complete vaporization of heavy fuels can be accomplished with oleophobic transpiration membranes(2,3) through which fuel can flow, but which differentiate the evaporation front from the liquid reservoir, and are able to equally pass all the gaseous phases of JP-8—with no partial distillates left behind. Capillary Force Vaporizers(4)—although open-flame combustion-heat driven—are one such example. The better vaporized the fuel is, the more completely and cleanly it will burn. Such a membrane will also render personal combustion devices orientation insensitive.

So that complete vaporization takes place and occurs at a sufficiently high rate, it is necessary to maintain the liquid-vapor phase boundary at temperatures in excess of 200°C. At these temperatures the surface tension of liquid JP-8 drops to 12 mN/m and the desired membrane must be oleophobic with “equivalent” surface energies sufficient for a liquid intrusion pressure of 3.5 kPa, an air flow capability of 83 sccm/cm2/kPa, and a thickness of 2 mm. These properties are sufficient to support devices with liquid fuel consumption rates in the range of 5–50 ml/hr, while keeping size small. In addition to the high temperature, the membrane material must also withstand the challenging chemical environment of vaporizing JP-8, which contains a wide variety of chemical species that are not well characterized or controlled.

Potential technology thrusts include: unique internal nanostructures; surface treatments or morphology(5) that influence surface energy; materials, such as inorganics(6) or sintered metals; and embedded catalysts or chemical additives. The requirement that the material can survive continuous service temperatures greater than 200°C while immersed in JP-8 without destructive chemical interaction will likely be the greatest challenge. The material shall be bondable to the surface of a ceramic.

PHASE I: Develop a proof-of-principle membrane capable of the performance described above. To establish proof-of-principle, materially demonstrate, through testing, the feasibility and practicality of the proposed material, including mitigation of risks associated with factors limiting system performance. A final report shall be delivered that specifies how requirements will be met in Phase II. The report shall also detail the conceptual design, performance modeling, safety and MANPRINT, and estimated production costs.

PHASE II: Refine the technology developed during Phase I, fabricate samples, and demonstrate how the goals of the project are met. Prototypes of different configurations will be integrated into heating devices to examine performance. Deliver a report documenting the theory, design, component specifications, performance characteristics, and any recommendations for future enhancement.

PHASE III DUAL-USE APPLICATIONS: Applications requiring heat of 50–500 W (170–1710 BTU/hr) will benefit from such a material integrated into their combustion systems. Immediate examples are open-flame or catalytic pocket-stoves, and personal heaters that would be popular in civilian camping, hiking, and winter sports. Other application include air heaters, water heaters, heat-driven refrigeration, and thermoelectrics. In general, membranes are an extremely useful technology for a wide variety of applications(7) that involve everything from purification to nanofiltration for difficult-to-separate gases, liquids and solids. Examples include desalination, reformers and fuel cells, reclamation of wastewater streams (including removal of oil and chemical contaminants), various industrial food and chemical processes, medical equipment, and electronics. Increasing the operating-temperature range for certain applications is a value-added outcome.

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2. Osmonics Membrane Filtration Handbook, Wagner, Jorgan, GE-Osmonics, (http://www.gewater.com/pdf/1229223-%20Lit-%20Membrane%20Filtration%20Handbook.pdf)

3. Pervaporation Membrane Separation Processes, Huang, Robert Y.M., (Membrane Science and Technology Series, 1), 1991, xii + 549 pp., ISBN: 0-444-88227-8, Elsevier, Amsterdam Oxford New York Tokyo (http://www.library.tuiasi.ro/ipm/vol11no12/biochemistry.html)

4. Capillary force fuels pocket stove, U.S. Army Soldier Systems Center-Natick, (http://www.natick.army.mil/about/pao/05/05-27.htm)

5. Surface modification of membranes for the separation of volatile organic compounds from water by pervaporation, Mohamed Khayet, Takeshi Matsuura, Department of Applied Physics I, Faculty of Physics, University Complutense of Madrid, Av. Complutense s/n, 28040, Madrid, Spain (www.desline.com/articoli/4640.pdf)

6. Inorganic Membranes for Separation and Reaction, Hsieh, H.P., (Membrane Science and Technology, 3) 1996, xvii + 610 pp, ISBN: 0-444-81677-1 Elsevier Science Amsterdam -Lausanne- New York - Oxford - Shannon - Tokyo
(http://www.elsevier.com/wps/find/bookdescription.cws_home/524617/description)

7. Membrane Separations Technology News, Business Communications Co., Introductory summary, (http://72.14.203.104/search?q=cache:6GDLkMrhwbMJ:www.mindbranch.co.kr/jp/ssk/contents/reports/report_content.asp%3Fs_id%3DN2-021+pervaporative+flux&hl=en&gl=us&ct=clnk&cd=49&client=firefox-a)

KEYWORDS: pervaporation, transpiration, membranes, combustion, battlefield-fuel, heating

A06-174 TITLE: High-Efficiency Heat Exchanger for Individual Stoves

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop heat-exchanger technology that will increase heat-transfer efficiency in personal stoves for heating water and melting snow.

DESCRIPTION: Individual stoves have been identified as an essential multipurpose item for heating water and rations, and for personnel hygiene. During cold weather operations, a personal stove can be necessary for survival. Commercial stove technology has advanced in recent years, producing models that are smaller, lighter, and easier to operate and maintain. A new JP-8 fuel stove based on Capillary Force Vaporizer (CFV) technology (see reference #1) sets new standards for size, weight, and ease of use. However, the heat-transfer efficiency has not improved, remaining about 30% efficient for typical use. Furthermore, slight cross winds can significantly decrease performance, as do small or odd cup shapes like the kidney-shaped canteen cup. Efficiency is tantamount to stove and fuel weight and time to heat water and rations to an acceptable temperature. Some stoves contain as much fuel as the dry weight of the stove itself. Doubling or tripling the efficiency provides weight savings, and the time required to heat water or melt snow is significantly reduced.

Since heat-transfer efficiency is largely a geometric function of the object being heated, a new technology is being sought for integration with a cup or pot, henceforth referred to as the Heat Exchanger Cup (HEXC), which improves the heating performance of stoves. Potential technologies include lightweight conductive materials and coatings, insulations and covers, high surface-area finned heat exchangers, microchannel heat exchangers, and catalysts that promote complete combustion. Catalysts may also reduce carbon monoxide, a combustion byproduct that is deadly when using stoves in confined spaces.

The HEXC shall hold at least 1/2 liter of water and fit snugly around the bottom of a standard 1 liter Nalgene brand polycarbonate bottle for compact transport. The HEXC shall be designed to work with the new CFV JP-8 fired stove, which has an output of 1.1-1.4 kW, and it should also be compatible with the Squad Stove (Optimus Nova and MSR Dragonfly, see reference #2). The HEXC shall weigh no more than 225 grams (150 grams desired). Minimum desired efficiency is 60% (75% desired), as determined by heating 454 grams of water from 4°C to 60°C in a cross wind of 8 km/h and dividing the energy added to the water (~106 kJ) by the heating value of JP-8 fuel consumed. The HEXC shall be safe to handle when hot by means of a cozy, insulation, wire handles, or similar; any exposed parts should cool quickly to minimize the potential for severe burns. The HEXC design shall not cause accumulation of soot or unburned hydrocarbons on exposed exterior surfaces. The water-contact surfaces shall allow proper cleaning and sanitation. The HEXC shall be robust enough for field use, not easily crushable by hand and capable of surviving an accidental one-meter drop when stored around the water bottle. The target production cost is less than $50.

PHASE I: Develop a proof-of-principle demonstrator capable of the performance mentioned above. To establish validity, materially demonstrate, through testing, the feasibility and practicality of the proposed design, including mitigation of risks associated with factors limiting system performance. A final report shall be delivered that specifies how requirements will be met. The report will detail the conceptual design, performance modeling, safety and MANPRINT, and estimated production costs.

PHASE II: Refine the technology developed during Phase I in accordance with the goals of the project. Fabricate and demonstrate an advanced prototype, verifying that the desired performance is met. Deliver a report documenting the theory, design, component specifications, performance characterization, and recommendations for technique/system performance. Provide prototype units suitable for display and Army field testing.

PHASE III: The outdoor recreational market for camp stoves is much larger than the military market. Any advances in system weight and efficiency can easily be marketed to outdoor enthusiasts, particularly campers, hikers, and mountain climbers. Stoves are also purchased for emergency use.

REFERENCES:
1) Modular Individual Water Heater fact sheet, http://nsc.natick.army.mil/media/fact/food/miwh.pdf
2) Squad Stove fact sheet, http://nsc.natick.army.mil/media/fact/food/squad_stove.pdf
3) Detail Specification MIL-DTL-83133E – Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35, and JP-8+100 (consult SITIS under this topic number for further information).

KEYWORDS: stove, campstove, combustion, heating, heat exchanger

A06-175 TITLE: <u>Highly Conducting Textile Fibers for Electro-Textile Applications.</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Fabricate 10-25 micron diameter textile-like fibers for incorporation, as wires, into electrotextiles. The fibers will have electrical resistance per unit length of not more than five times that of a copper wire with a diameter equal to 60% of the fiber diameter and be electrically insulated. The fibers will have sufficient durability to be spun into yarns and then woven, knitted, or braided into fabrics for electrotextiles.

DESCRIPTION: At the present time there is a need for electrically shielded cables to be incorporated into textiles to carry both data and power. Wireless devices are appealing but require too much power, are subject to high levels of electromagnetic interference, and crosstalk among devices. Unfortunately, all of the current cable based solutions have a number of serious drawbacks. In general they are not incorporated directly into the textile but rather attached via some means such as an adhesive to the fabric. The result is a garment that is not as comfortable (flexible) as a traditional textile, has cabling that can catch on other items, and because the metal wires are subject to repeated stresses, is subject to frequent failure due to metal fatigue. The bending stress is a function of the diameter of the wire so a finer diameter wire (fiber) is subject to less bending fatigue and so less prone to failure. To limit metal fatigue requires large strain isolation connectors to reduce flexing at interconnections and provide a place to grip for connection and disconnection (rather than just pulling on the cable). The problem of metal fatigue and the need to isolate the wire to connector junction from stress in disconnecting leads to the requirement for large bulky connectors.

A number of conducting yarns are available commercially, for example, yarns containing 20% stainless steel are produced by Bekeart as Bekitex BK50. Unfortunately, while stainless steels have good flexibility and corrosion resistance they are very difficult to solder and stainless steel has low electrical conductivity. The 316L stainless steel used in Bekitex BK50 has an electrical conductivity of less than 2.5% of that of copper. A yarn with similar electrical resistance using indium metal would require less than 5% metal. Even this comparison overstates the effectiveness of the stainless steel yarn since the stainless steel fibers in the yarn are staple fibers not continuous filaments so they will have increased electrical resistance because current must be conducted from one filament to the next. Titanium wires are not subject to metal fatigue but are much more expensive than stainless steel and their electrical conductivity is only about 4.5% of that of copper. Newer materials such as carbon nanotubes may in the future offer a solution but at the present time they are extraordinarily expensive and there are concerns about health effects. A good discussion of the state of the art can be found in reference 1.

The proposal seeks to develop insulated wires with textile fiber size and properties as well as low electrical impedance. These conducting fiber textiles would be suitable for spinning into textile yarns and then woven, knitted, or braided into fabrics for electrotextiles. These fibers could potentially be used as either a conducting core or low to moderate frequency EMI shielding in a cable. Using a soft metal causes the loads to be carried naturally by the polymeric materials. Limiting metal fatigue allows the use of smaller connectors. The ultimate goal (perhaps beyond the scope of this project) is to produce a textile fabric with embedded USB 2.0 capability.

This research is innovative in that the wires are below the size of conventionally drawn and coated metal wires. Moving the technology down to a textile fiber size will allow for the integration of wires into textiles while maintaining textile handling and manufacturing properties. By using textile fiber spinning processes the cost of mass producing very small wires can be kept low. At this time at least one company can spin a bicomponent fiber with a metal core and an insulating polymer sheath; however, the metal is toxic (contains cadmium and lead) and comprises only a small fraction of the fiber cross section.

PHASE I: The Phase I effort would seek to demonstrate that a fiber with suitable properties and the capability to be mass produced for incorporation into electrotextiles can be made. An illustration of this would be to use bicomponent fiber spinning to spin a metal core polymeric sheath fiber (but the approach is not restricted to bicomponent fiber spinning). The metal could be a low temperature lead free solder such as Indium (electrical resistance about four times that of copper). It would be necessary to demonstrate that a fiber of suitably low electrical impedance and fine enough diameter could be produced by a high production rate process. That demonstration could be by actually producing such a fiber by a high throughput process or providing convincing evidence that such a fiber can be produced. Deliverables for Phase I would be at least one meter of a suitable fiber and a technical report detailing the development and manufacturing parameters for such a fiber.

PHASE II: Phase II effort would involve scale up and optimization of fiber production as well as the incorporation of those fibers into sample textile materials. The phase II prototypes would need to demonstrate both suitably low electrical impedance and large scale manufacturing. For example, Phase I may have demonstrated that a one meter sample of suitable fiber can be produced; however, it is necessary to produce thousands of meters of fiber with an acceptable level of defects in order to produce a commercially viable product.

PHASE III: There would be many dual use applications for a fiber with these properties. Possible dual use applications would be electrically heated garments (blankets, gloves, etc.), outdoor clothing such as snowboarding jackets with built in music players, and industrial applications such as “smart” clothing for electrical and communication workers.

REFERENCES:
1) D. Meoli and T. May-Plumlee “Interactive Electronic Textile Development: A Review of Technologies” J. Textile and Apparel, Technology and Management Vol. 2 Issue 2 Spring 2002, http://www.tx.ncsu.edu/jtatm/volume2issue2/articles/meoli/meoli_full.pdf

KEYWORDS: electronic textiles, conducting fibers, wearable computing, wire, fiber

A06-176 TITLE: Wearable Electronic Network Made from Discrete Parts

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop materials and/or methods to impart or maintain network conductivity in a garment or clothing system made from multiple discrete fabric pattern parts.

DESCRIPTION: Most recently several types of wearable electronic textiles have been developed for personal use. Two selected military applications are textile-based Universal Serial Bus (USB) 2.0 cables that support a wearable electronic network providing data and power transport, and a textile-based double loop antenna. These electronic narrow woven fabrics (1 – 2 inches wide) can be used to create a continuous network on or within a garment or clothing system and are terminated only at the ends. In addition, a stretchable, body conformal t-shirt was developed with an integrated spiral bus that serves as a platform to integrate medical instrumentation and/or sensors that are required to be in close contact with the body. The continuous bus within the fabric wraps around the torso and is terminated at the ends. Narrow fabrics and knits, which are the fabric construction types used in these applications, are used less frequently than broadloom woven fabrics in combat clothing or industrial protective clothing. Broadloom fabrics provide the greatest flexibility in functionality of garment design, durability, and the application of camouflage print technology. However, while conductive materials such as stranded copper wire, tinsel wire, and metallic coated synthetic fibers can easily be integrated into broadloom fabrics the conductive path is lost when pattern pieces are cut and sewn together to form a three dimensional garment. The objective of this topic is to develop materials and/or methods to impart or maintain network conductivity in a garment or clothing system made from multiple discrete parts. In addition, the conductive pathway shall support the attachment of electronic subsystems such as sensors or other devices. The finished product, a wearable garment, shall be comfortable to wear, washable, and durable to wear and tear.

PHASE I: The technical feasibility to develop materials and/or methods to impart or maintain network conductivity in a garment or clothing system made from multiple discrete parts shall be established. Methods to develop novel materials such as flexible wearable conductive solder or adhesives, or manufacturing methods for innovative seaming or joining techniques shall be investigated. Test methods shall be proposed to evaluate seam strength, flexibility, and conductivity, as well as washability and durability. The networked clothing system shall be safe to wear, lightweight, comfortable, and electromagnetic interference (EMI) shielded. A garment or clothing system's level network shall be mapped, designed from discrete parts, and proposed. The most effective designs, materials, manufacturing processes, and test methods will be determined and proposed for Phase II efforts. A report shall be delivered documenting the research and development supporting the effort along with a detailed description of materials, processes, and associated risk for the proposed Phase II effort.

PHASE II: The contractor shall develop, demonstrate, and deliver one working prototype of the networked garment or clothing system with performance in accordance with the goals described in Phase I. The novel seams shall demonstrate a seam efficiency of not less than 80 percent when tested in accordance with ASTM D 1683. The networked system shall meet the requirements for the control of electromagnetic interference characteristics of subsystems and equipment in accordance with MIL-STD-461E. A report shall be delivered documenting the research and development supporting the effort along with a detailed description and specifications of the materials, designs, performance, and manufacturing processes.

PHASE III: Electronic textiles have potential commercial application in wearable communications gear and GPS for firefighting, law enforcement, first responders, and urban search and rescue; medical devices such as vital signs monitoring; foreign military; fashion clothing; simples toys and novelties.

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1) C. Winterhalter, J. Teverovsky, P. Wilson, J. Slade, B. Farrell, W. Horowitz, E. Tierney, "Development of Electronic Textiles to Transport Data and Power in Future U.S. Military Protective Clothing Systems," Journal of ASTM International, July/August 2005, Vol. 2, No.7.
2) C. Winterhalter, J. Teverovsky, W. Horowitz, V. Sharma, K. Lee, "Wearable Electro-textiles for Battlefield Awareness," Proceedings of the 24th Army Science Conference, December, 2004.
3) "Electronics on Unconventional Substrates – Electrotextiles and Giant Area Flexible Circuits," Materials Research Society, editors S. Shur, P. Wilson, and D. Urban, Volume 736, Symposium Proceedings Fall 2002.

KEYWORDS: electronic textiles, personal area network, textile power bus

A06-177 TITLE: Combined Heat and Power System (CHPS)

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a multifuel Combined Heat and Power System (CHPS) that can operate on a wide range of alternative fuel sources from the low density producer gas of a waste gasifier to high density diesel fuel.

DESCRIPTION: Military aircraft and ground vehicles depend on the availability of JP8. Organizational equipment systems such as kitchens, laundries, showers, and space heating have also standardized on this single battlefield fuel. However, these systems could be operated on many types of fuels including incinerated or gasified waste and biofuels. By giving these "heat-driven" systems the ability to operate on alternative fuels and local fuels, the military will have more JP8 available for air and ground vehicles.

CHPS shall consist of a burner, thermal fluid heat exchanger, and electric power generator. The burner shall be capable of combusting a wide range of gaseous and liquid fuels, automatically adjusting for different fuel densities and air requirements. The thermal fluid heat exchanger shall be capable of extracting at least 75% of the heat combustion. The power generator shall be coupled to the heat exchanger and shall convert at least 10% of the heat to electric power (20% desired). It is also desired that the heat used by the generator be exhausted at a useful temperature of at least 100°C (212°F) (116°C (240°F) desired). Commercial incinerators (used for medical and biowastes) will be considered responsive if it can be demonstrated that wet scrubbers are not required to meet EPA clean air standards (bag filters can be used for particulates). The CHPS shall be designed to produce a nominal 90kW (approx 300kBTU/hour) heat energy at 260°C (500°F) and 7.5kW electric power (15kW desired). Noise levels at 1 meter (approx. 3 feet) shall be 75dBA or less (65dBA desired).

Possible electric power generation technologies include, but are not limited to, stirling engines, Closed Rankine Cycles (CRC), Closed Brayton Cycles (CBC), or high efficient thermoelectric generators (TEGs).

PHASE I: Research, develop, and design a CHPS that will meet the requirements stated above. Conduct the necessary engineering analysis on the critical components to demonstrate the feasibility and practicality of the design. Weight shall not be more than 90kg (approx. 200 lbs) and cube shall not be more than 0.1m3 (approx. 4 ft3). Conduct risk and safety analyses on the design to identify and mitigate any potential environmental, operational, or logistical risks. High reliability, low maintenance, and minimal noise are important characteristics that shall be featured in the design. Deliver a final report documenting the research and development effort, along with a detailed description of the theory, the design, and specifications.

PHASE II: Develop the system identified in Phase I. Fabricate a prototype system and demonstrate it in a controlled environment. Evaluate and characterize the performance, then refine the design in accordance with the requirements stated above, update the prototype, re-test, demonstrate, and deliver the complete system.

PHASE III: The demand on reduction of fossil fuels, increase on power demand and consumption serve as a great application for a CHP system. CHP systems are more efficient than regular methods, thus decreasing the amount of fuel needed to do the same operation using conventional methods. CHP systems approach residential and business applications where the system could be coupled to the heating system. Businesses could practice distributed generation. Distributed Generation permits the businesses, which are generating electricity for their own needs, to send their surplus electrical power back into the power grid. This safeguards their supply and reduces their cost. This application is especially needed on hospitals where a reliable source of energy, heating for air conditioning and hot water is required.

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1) Hurley, J. R., Feasibility Study and Development of Modular Appliance Technologies, Centralized Heating (MATCH) Field Kitchen, US Army Natick RD&E Center, Technical Report Natick/TR-94/023, July 94.
2) Website: http://www.aceee.org/chp/, Combined Heat and Power and Distributed Generation, American Council for an Energy-Efficient Economy, July, 2005.
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KEYWORDS: CHP, Thermoelectric, Turbine, Waste Heat, Rankine Cycle, Brayton Cycle, Thermal Fluid, Kitchen

A06-178 TITLE: Development of Phage Technology Effective Against Biological Pathogens for Foods

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: DoD Combat Feeding

OBJECTIVE: The development of novel, environmentally-friendly, non-chemical approaches for improving the safety of various food products that have been naturally or intentionally (e.g., bioterrorism) contaminated with various pathogenic bacteria.

DESCRIPTION: U.S. troops are deployed worldwide to places where commercial food sanitation standards may be inferior and enforcement of those standards is lenient. Food can be used as a delivery system for the deployment of biological weapons by hostile states or terrorist organizations. These agents can also be present due to poor food handling or preparation. The ability to prevent biological pathogens in food is paramount in providing a complete and integrated food security plan for the Department of Defense. Perishable foods, such as fresh fruits and vegetables are procured from host or neighboring nations from so called “approved sources”. The result is that food-borne disease outbreaks become a considerable threat and could have a significant impact on overall troop performance and readiness. Incidence of diarrhea among warfighters results in lost workdays and decreased abilities to perform their duties. Gastroenteritis caused by enterotoxigenic E. coli and Shigella (49.5%) frequently interfered with the duties of U.S. troops during Operation Desert Shield. Presently, there are no guaranteed procedures available to prevent warfighter’s exposure to diarrhea causing organisms because of inherent difficulties with sample preparation for detection of low pathogenic concentrations from foods. Decontaminating foods presents considerable challenges, particularly when traditional disinfection techniques are only 90 to 99% effective (Sapers 2001) and may themselves damage or imperil those foods. Thus, fielded, novel, environmentally-friendly, non-chemical approaches for improving the safety of various food products that have been naturally or intentionally (e.g., bioterrorism) contaminated with various pathogenic bacteria needs to be developed for application at the procurement sites. Bacteriophages are bacterial viruses that attach to their specific bacterial host and kill them by replicating inside the organism resulting in cell lyses and death. Phages were extensively used therapeutically in humans prior to the development of antibiotics and are presently being studied for their application to foods. A petition for their use in foods has recently been applied for by Intralytix, Inc. for use on meat products based on research conducted with USDA. http://www.cfsan.fda.gov/~dms/opa-expd.htm

PHASE I: Conduct research and development of bacteriophage preparations lethal against genetically diverse strains of common food pathogens. Development in Phase I should be for phage preparations specific against at least one of these common food pathogens (E. coli 0157H7, Campylobacter, or Shigella). Proposals should include methodology to evaluate the initial proof-of-concept of phage biocontrol strategies on whole intact fruits and vegetables, identify the mechanism(s) of action of their specific phage-based preparations, as well as conduct stability studies to ensure phage viability and lethality on tested food products. Research efforts must focus on providing a minimum 3 log reduction of the test pathogen from at least one fruit and one vegetable surface. Results from Phase I research should demonstrate the feasibility and specificity of the phage preparation against at least one food pathogen on at least two food matrices. Lastly compare the efficacy of the phage preparations against traditional sanitizing technologies against the selected target pathogen on one fruit and one vegetable. Deliver a report documenting the research, development and results of the effort.

PHASE II: Characterize all promising monophages in order to construct optimal phage cocktail(s) of phage preparations from Phase I against selected target pathogen(s). Generate information required and conduct studies for scale-up production of monophages. Demonstrate reproducibility. Gather and prepare information that will be required by regulatory agencies, such as toxicity testing, of the phage preparation(s) for future Food Additive Petition submission to FDA. Deliver a report documenting the design, optimization and scale-up and safety of the phage cocktail preparation(s).

PHASE III: Conduct commercial scale-up production of phage preparation(s) using GMP to ensure compliance and safety for food application. Prepare Food Additive Petition package and submit to FDA for FAP application. Development of environmentally-friendly, non-chemical approaches for improving the safety of various food products would be applicable in both military and civilian sectors for protection against naturally or intentionally contaminated foods. Department of homeland security, Food and Drug administration and U.S. Department of Agriculture would benefit greatly from this effort as well as commercial food companies.

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KEYWORDS: bacteriophages, pathogens, food safety, enteric disease, diarrhea, bacterial viruses, foodborne illness, antimicrobial technology

A06-179 TITLE: UV Resistant Synthetic Polymer Fibers

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop and apply novel materials and processing techniques to commodity polymers to produce synthetic polymer fibers that are not degraded by extended or repeated exposure to UV radiation.

DESCRIPTION: Synthetic polymer fibers are a critical component of many Soldier System equipment items, including clothing, armor, soft shelters, and airdrop equipment. Synthetic fiber materials used in Army systems include polyamide (nylon), polyolefin, polyester and polyaramid. These fibers have varying susceptibilities to degradation by UV radiation, but all are affected to some extent by extended UV exposure. In the case of polyamide in particular, significant loss of fiber strength can occur after relatively short exposure to solar UV radiation, as might be experienced by shelter fabrics deployed in a desert environment or by parachute canopies repeatedly deployed at high altitudes or left exposed to solar radiation prior to recovery. In one study of military fabrics exposed to tropical sun, the break and tear strength values of nylon/cotton blend fabric fell more than 40% (to values below minimum performance specifications) in just two weeks [1]. Protection of polymer materials from UV radiation is frequently accomplished by adding UV-absorbing or UV-opaque compounds to the polymer during processing, which results in a more or less uniform distribution of the UV absorber throughout the polymer. In fibers, the cross section of the individual filaments is so small (typically 10's of micrometers) as to render this approach ineffective except at very high loadings of UV absorber, which of itself compromises the mechanical properties of the fiber. Another common approach to polymer protection from UV radiation is to apply a UV-opaque coating to the part to prevent exposure of the polymer to the UV radiation. In the case of fibers, applying a thin, uniform, adherent coating to individual filaments is challenging, though commercial UV protective coatings for fabrics exist. These products have the drawback of being applied in the field with limited process control, require training in correct application, contain hazardous materials, and can add substantial weight to the fibers or fabrics. This approach also has the disadvantage that the protective coating can be removed by weathering or by wear or other mechanical damage, exposing the unprotected substrate. What is needed is an approach to creating synthetic polymer fibers from commodity polymers that are inherently resistant to UV radiation without the drawbacks of current commercial approaches. It may be possible to accomplish this objective using novel fiber designs such as bi-component sheath/core or other novel fiber cross sections that limit the access of UV radiation to the filaments. The use of nanotechnology may also be a promising approach to the problem, in that nano-scale additives may be more effective at attenuating UV radiation at lower loading levels than commonly used UV-absorbers. A combination of approaches involving the use of novel additives, processing techniques, polymer blending and fiber cross section design may be needed to achieve success, and this topic description is not intended to mandate a specific approach to this problem. Metrics for success include the enhancement of UV radiation stability of synthetic polymer fibers compared to commercially available UV resistant fibers of similar type, while simultaneously not degrading any functional capabilities of the fibers, particularly tensile strength, tensile modulus and elongation to break, that are critical to fiber performance in a given application.

PHASE I: Develop innovative technology to create continuous polymer fibers or yarns with enhanced resistance to degradation by UV radiation (typical solar spectrum) compared to commercially available UV-resistant fibers or fabrics, while providing the same or better levels of performance as the commercial reference materials in properties of tensile strength, tensile modulus and elongation to break. Demonstrate the developed technology in lab-scale testing.

PHASE II: Further develop the technology identified in Phase I. Optimize parameters and scale up the manufacturing process to demonstrate the ability to produce multi-pound quantities of UV-stable fiber at rates comparable to commodity fiber or yarn production processes (> 1000 m/min) with consistent quality. Demonstrate the potential and feasibility to scale up the process to full-scale commercial production, meeting fiber performance and cost goals (performance and cost comparable to commercial reference fibers, but with enhanced resistance to degradation by UV radiation).

PHASE III: Fiber materials are used in a wide variety of military and civilian applications that require repeated or extended exposure to UV radiation. Examples include clothing, parachutes, soft shelters, hot air balloons, ultralight aircraft, sail cloth and ropes. A UV-stable fiber that improves the useful lifetime of these products should have excellent commercial potential.

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KEYWORDS: polymers, fibers, degradation, UV resistant, nanotechnology

A06-180 TITLE: Ethylene Control in Fresh Fruits and Vegetables

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop technology to control ethylene produced by fresh fruits and vegetables transported and stored in refrigerated containers.

DESCRIPTION: Fresh Fruits and Vegetables (FF&V) are an essential dietary supplement to standard operational rations. Mixed cases of FF&V are transported and stored in refrigerated containers. As FF&V ripen, they produce and release ethylene which accelerates ripening and spoilage. Some fruits, such as bananas and apples, produce very high levels of ethylene which leads to the acceleration of ripening and spoilage of other FF&V within the container. Concentrations as low as 0.1 ppm can affect the ripening process and ethylene gas levels as low as 1 ppm can destroy an entire shipment in a single day (see Reference 1). By controlling ethylene the storage life of FF&V can literally be extended from days to weeks. For example, the shelf life of bananas can be extended from 3 days to 15 days or more. The FF&V industry currently uses blankets and packaged pellet sachets of an ethylene adsorbent to control this problem. The Navy has used adsorbent blankets in the past but has since determined that the logistics of stocking, using, and disposing of these materials is too much trouble and their use has subsequently been discontinued. The logistics of maintenance and disposal of these products is also not practical for Military mobile applications. Current ethylene control technology is based on the use of ethylene adsorptive materials that are one-time-use, relatively bulky and heavy, and pose a considerable environmental and cost burden as the spent permanganate-based materials are considered a hazardous waste. Furthermore, these products are not suited for use in a military environment, where storage space and logistic support is very limited. Accordingly, a non-consumable device that can be installed or placed in a refrigerated container that will automatically control the level of ethylene is needed to ensure that FF&V can be stored long enough to be served. Though not a requirement, the ability to detect ethylene, or monitor a minimum set point concentration, within the container may further enhance the Services' ability to reduce FF&V spoilage and losses in storage and transit.

The propopsed Ethylene Control Technology (ECT) shall be designed for a standard 20 foot ISO refrigerated container having an internal storage capacity of 820 cubic feet. It shall interface with the air circulation system near the evaporator and require less than 3 cubic feet, or 0.3 % of the storage capacity. It shall be capable of converting the ethylene to harmless products to maintain a container atmosphere of less than 0.1 ppm ethylene. One possible approach is to catalytically oxidize ethylene to acetic intermediates and ultimately to carbon dioxide by: $O + C_2H_4 \rightarrow CH_3CO- \rightarrow CO_2$. In addition, the ECT shall be capable of continued operation with maintenance intervals of 6 months or longer. The ECT shall require no more than 100 watts of power. The target production cost is $500 or less.

PHASE I: Develop a proof-of-principle demonstration capable of the performance outlined above. To establish validity, materially demonstrate, through testing, the feasibility and practicality of the proposed design, including mitigation of risks associated with factors limiting system performance. A final report shall be delivered that specifies how requirements will be met. The report will detail the conceptual design, performance modeling, safety and MANPRINT, and estimated production costs.

PHASE II: Refine the technology developed during Phase I in accordance with the goals of the project. Fabricate and demonstrate an advanced prototype, verifying that the desired performance is met. Deliver a report documenting the theory, design, component specifications, performance characterization, and recommendations for technique/system performance. Provide a prototype to support Army technical and field testing.

PHASE III: The natural process of ripening and spoilage of fruits, vegetables and flowers releases ethylene gas. As a ripening hormone, ethylene further accelerates the ripening and spoilage process at concentrations greater than 0.1 ppm, which is equivalent to 1 cup of ethylene in 0.62 million gallons of air. Therefore, the control of ethylene in storage and processing is a prerequisite to providing ultimate quality to the consumer and in achieving desirable economic benefits to the producer, distributor and retailer. Year–round availability of high quality fresh fruits, vegetables and flowers depends on a vast infrastructure of refrigerated transportation and storage facilities. Commercially available systems for monitoring and controlling airborne ethylene concentrations below 1 ppm are very costly and oversized, limiting their commercial usefulness. An inexpensive device that destroys (and possibly monitors) ethylene in stead of adsorbing it would be easier to use and would avoid disposal issues. Commercial warehousing, transport, and retailer storage of FF&V will benefit from this technology and early partnering should be pursued.

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KEYWORDS: ethylene, fruits, vegetables, storage, rations, refrigeration

A06-181 TITLE: Pressure Measurement System for Parachute Fabrics And Other Textiles

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The objective of the topic is the development of a pressure measurement system to measure the aerodynamic pressure on the surface of a parachute canopy or other textile item. The motivation of this topic area is based on the need to measure the pressure on the surface of a parachute canopy fabric for verification and validation of fluid structure interaction computer simulations of parachutes.

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 and verified with test data to ensure accurate prediction results from the simulation. The validation of the parachute canopy aerodynamics in the simulation would be greatly aided by detailed knowledge of the temporally evolving aerodynamic pressure field on the entire surface of a parachute canopy.

This solicitation is open to all suggested solutions to the topic but two possible approaches to the problem is the development of pressure sensitive fabric or the development of small lightweight ultra-low pressure sensors which would be attached to the canopy surface. Any solution should try to be applicable to a range of parachute canopy scales from small-scale canopies (0.3 m diameter) for testing in a laboratory, to full-size canopies (30 m diameter) for testing in an airdrop operation. The pressure measurement system should be able to measure differential pressures across the canopy surface of 0-3500 Pa (0-0.5 psi) for full-size canopies and 0-140 Pa (0-0.02 psi) for lab-scale canopies and should be able to discern pressure levels of 0.25% of the full-scale reading.

The suggested pressure sensitive fabric solution would have similar properties to pressure sensitive paints. Pressure sensitive paints have been used to measure the fluid pressure on the surface of a body exposed to a flow at high dynamic pressure. The use of pressure sensitive paints for accurate low speed measurements has also been accomplished. However, in both of these conditions, the paint must be applied to a fixed, rigid body in order to obtain valid results. Application of the paint to a fabric would not present ideal testing conditions and it would also alter the properties of the fabric. It is therefore desired to develop a pressure sensitive fabric that could be used in parachute research and other textile applications where knowledge of the fabric surface pressure is desired. Typical parachute research is conducted using the Army standard 1.1 oz/sq. yd. nylon fabric. The pressure sensitive fabric should match the properties (strength, permeability, weave pattern, etc.) of the standard fabric as closely as possible. The variation of the surface pressure should result in variations of the optical appearance of the fabric, similar to the behavior of the pressure sensitive paints. Interest in the transient pressure on the canopy surface is desired; therefore the fabric should have a pressure temporal response on the order of 0.01 sec. While it would be desirable to discern pressure levels as low as 0.5 Pa, solutions with lower resolution would be considered.

An alternate suggested topic solution would be the development of an ultra-low pressure sensor which could potentially operate within a network of other sensors. While low pressure sensors exist in the commercial market, they are typically large in size and weight making them impractical for implementation in parachute pressure measurements. The design and construction of the pressure sensor should be such that it could be embedded into the canopy material and would measure the aerodynamic pressure differential across the textile. Any applicable technology (such as nanotechnology, Micro-ElectroMechanical System (MEMS), or other technologies) could applied as a solution. The sensor should have adequate flexibility so as not to significantly alter the overall characteristics of the textile. This requirement could be met by just the size of the sensor alone. It should contain its own power source or alternative innovative methods for powering the sensor could be proposed. In order to obtain ample aerodynamic pressure data on the canopy, it would eventually be necessary to instrument the canopy with multiple sensors at multiple locations on the canopy. It is therefore desired to have the individual sensors distributed over a large area of the canopy surface. This suggests the sensor needs to operate within a large array of other sensors (with the number of sensors being on the order of hundreds or possibly thousands, depending on the size of the canopy). The sensor should communicate wirelessly with a central processing control unit within 70 meters of the sensor or record its measurements onboard for data collection at a later time. The sensor could be used in additional applications if it also measured one or more other parameters such as temperature, viscosity, acceleration, or heat flux, to name a few. Moreover, the sensor would have considerably more applications if it could operate in wet environments. In addition to the pressure range and sensitivity specified above, the sensor should meet the following physical and performance parameters:

- Dimensions: lateral dimension <5 – 10 mm; thickness < 0.25 mm
- Weight: match areal density of fabric, 1.1 – 2.2 oz/sq. yd.
- Data rate: 50 Hz minimum sustained, 1000 Hz burst mode during parachute opening
- Power: self-contained desired
- Data transfer: wireless connection to central processor/data logger within 70 m distance or self-contained recording capabilities
- Array: works in a network with a large number of other pressure sensors on the canopy (500 – 1000 sensors)
- Frequency response: 1000 Hz
- Shock loading: up to 10 G acceleration

While two potential solutions to the topic have been suggested, all other methods and concepts for the development of low pressure aerodynamic measurement system on a flexible body will be considered. It is highly encouraged that other advanced pressure measurement systems and/or sensors be proposed for solutions to this topic.

PHASE I: In this phase, system designs should be developed and laboratory demonstrated. Proof of concept demonstration of an individual sensor or sensing elements are acceptable as opposed to sensors operating within an array. However, the feasibility of developing the system to meet the topic requirements for field testing outside of controlled laboratory testing should be analyzed and demonstrated (including operating within a network of other sensors if applicable). Analyses should be conducted to substantiate the achievable performance of a fielded system for the possible use on small-scale parachutes through full-size canopies. A study should be conducted that establishes the relationship among cost, system performance, reliability, and robustness over all desired testing conditions.

PHASE II: In this phase, a prototype systems should be field-demonstrated on a range of canopy scales from small-scales to full-size parachutes deployed from an aircraft. Based on the results of all analyses and test results obtained, designs should be revised and retested to better meet performance requirements. A pre-production system should be built, field-demonstrated under realistic operational conditions, and its performance evaluated. A working prototype system should be delivered at the conclusion of Phase II.

PHASE III: Commercial applications include any use where pressure measurements are needed on a textile or other flexible material such as tents, clothing, shoes, skin, sails, kites, etc. The system also has applications where a large array of sensors are needed over an inaccessible region where it would be impractical to instrument the region with traditional sensors.

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KEYWORDS: pressure measurement, airdrop, parachutes, instrumentation, aerodynamics, pressure sensor

A06-182 TITLE: Flow Field Measurements and Visualization for Full Scale Parachutes

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The objective of the topic is the development of advanced flow field measurement tools and techniques to investigate the airflow around large scale rigid and flexible objects, such as parachutes.

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 the initial development of airdrop systems. These computer models need to be validated and verified with test data to ensure accurate prediction results from the simulation. The validation of the parachute canopy aerodynamics in the simulation would be greatly aided by detailed knowledge of the temporally evolving flow field around a parachute canopy. Measured flow data around a parachute canopy would be used to properly establish the input boundary conditions in the numerical simulations being validated. Additionally, a direct comparison of the measured flow fields with the output of the simulations can be made to ensure the simulation are generating accurate and reasonable results. A lack of flow field visualization and measurements during full-scale parachute testing hampers full evaluation of parachute design, causing the need for unnecessary costly full-scale testing.

A modern flow field measurement technique typically used in laboratory-based experiments is Particle Image Velocimetry (PIV). Two or three components of the velocity can be measured in a single plane using commercial-off-the-shelf PIV systems. However, in order to obtain adequate spatial resolution of the measurements it is often necessary to limit the spatial region of interest to regions on the order of 0.7 ft x 0.7 ft which in turn limits the size of the object whose flow field is being interrogated. It is desired to develop methods and techniques for measuring the flow field in larger regions of interest while maintaining spatial and temporal resolutions comparable to existing flow field measurement techniques. The minimum desired region would be on the order of 7 ft x 7 ft or larger. While large scale PIV methods would be an acceptable solution, other techniques and methods would be considered as a solution to the topic as well. Similarly, proposed solution should not be limited to planar measurements if other measurement techniques would provide the desired data and knowledge.

Typically flow field measurements are conducted in a wind or water tunnel environment in highly controlled laboratory conditions. However only limited parachute research can be conducted in these environments due to the limited size and the constant inflow condition created by most wind tunnels. Parachutes create very rapid decelerations which are difficult to recreate accurately in a wind tunnel. Therefore, parachute research is often conducted in large enclosed structures (such as blimp hangars) in which parachutes are allowed to free drop in a reasonably quiescent conditions. Testing being conducted in these buildings minimizes the effects of atmospheric conditions (such as atmospheric winds) on the tests while still allowing for testing of moderate scaled parachutes. It is therefore desired to develop new large scale flow field measurement techniques into the free drop testing environment where the flow field measurement would be made at a fixed region while the parachute canopy would be allowed to pass through the region. The challenge of transitioning from a wind tunnel testing environment to free drop conditions introduces many difficulties in the development of the system including (but not limited too) its robustness, portability, power requirements, and environmental lighting conditions (i.e., the system may be deployed in conditions where achieving complete darkness would be difficult). The developed system may need to be suspended from a platform as high as 150 ft above ground at several fixed regions along the path of the parachute during its opening and steady descent. Alternatively the system could be mounted onto a moving carriage which tracks the motion of the parachute. The minimum parachute specifications in which these techniques and methods would be applied are:
• Parachute: 7 ft diameter flat circular
• Descent rate: 45 ft/sec

The expected flow field velocity range which the system should be able to measure is 0 – 60 ft/s with an accuracy on the order of 5-10%. The temporal resolution of the measured flow field should be comparable to current field measurement systems (i.e., 15 fields/sec) although other rates would be considered. The spatial region which is to be measured is a minimum of 7 ft x 7 ft with a minimum velocity vector spatial resolution of approximately 1-2 inch. Larger measurements regions with comparable spatial resolution are desired but the system should meet these minimum requirements. As mentioned earlier, it is highly desirable that these techniques and methods could be expanded to full-scale parachute testing from an aircraft.

PHASE I: In this phase, specifications for the methods and techniques proposed should be developed. Hardware, software, and methodology should be developed for testing the technique at typical laboratory scales. The proposed techniques should be employed on canonical flow problems (i.e., cylinder problem or other such problems) at laboratory scales to verify the accuracy of the method. A feasibility study should be conducted on scaling the methods to larger moderate sized parachute testing in an enclosed structure.

PHASE II: In this phase, the technique should be scaled to regions of interest large enough to test moderate scale parachutes. In order to verify the technique at the larger scales, canonical flow problems should be investigated. Once the technique has been verified, it should be applied to a moderate scale parachute in a controlled environment (i.e., wind tunnel or similar conditions) and then in a free drop environment in an enclosed building. Feasibility and capability of scaling the technique to full-scale parachute should also be investigated. A working prototype system should be delivered at the conclusion of Phase II.

PHASE III: Large scale flow field measurement techniques have extensive commercial applications, such as airflow investigation of commercial aircraft, helicopters, ships, hot air balloons, buildings, natural environment, etc. therefore, dual use of the measurement techniques are immense.

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KEYWORDS: Flow field measurements, instrumentation, aerodynamics, airdrop, parachutes

A06-183 TITLE: <u>Light Weight Fabric for Parachute Modeling</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop and apply novel materials and innovative design techniques to fabricate a light weight and low porosity fabric for the construction of models of flexible parachute canopies. Demonstrate the properties of the fabrics and the capability of the model parachutes to simulate the performance of full-scale parachutes.

DESCRIPTION: Airdrop tests of full-scale parachutes from an aircraft to evaluate their performance and to develop new parachutes are expensive and time consuming. Prediction of the performance of full-scale parachutes and their simulation using scaled models in a laboratory present obvious advantages in cost and time savings. Many analytical and experimental modeling investigations to predict the performance of full-scale parachute using small-scale parachutes and the correlation between the two have been conducted. These investigations have produced some useful dimensionless groups in terms of fabric properties and test parameters for the scaling between the two scales. However, all these investigations point to one single deficiency and that is the lack of a light weight fabric to fabricate parachute models. Typical full-scale parachute canopies are made of nylon having an aerial density of 1.1 oz/sq. yd. and an air permeability of 100 cu. ft./min. at a 0.5 in. air pressure (full-scale nylon). If the full-scale nylon is used in parachute models, they tend to be stiff and do not reproduce the flexibility and performance of full-scale canopies. Analytical modeling investigations (References 1 and 2) indicate that parachute canopy flexibility is a strong function of fabric properties. In particular, for a ¼-scale parachute model of a full-scale parachute, the aerial density and the air permeability of the canopy fabric have to be reduced by a factor of four, and the strength reduced by a factor of sixteen. While these scaling laws have not been demonstrated experimentally (simply because such a fabric does not exist), they can be used as guidelines in developing the new fabric. This technology barrier of the unavailability of light fabrics for parachute modeling has presented a major difficulty for a very long time in full-scale parachute performance prediction using small-scale models. However, with the recent advances in new fabric material development and fabrication technology, light weight fabrics are very plausible. Examples of these advances include nonwoven fabrics and nanofibers. Nonwoven fabric design processes are now very flexible and can systematically vary fabric aerial density and permeability. Candidate processes include spunbonded, spunlaced, and the combination of nanofiber meltblowing and electrospinning. Since fiber stiffness depends on the fiber diameter, fabrics made from nanofibers with diameter less than 1 micrometer should offer various degrees of flexibility to match that of a full-scale parachute canopy. Therefore, fabrication of fabrics made of nanofibers using nonwoven fabric manufacturing technology appears to be a very feasible approach to achieve a flexible fabric with a low density and low permeability.

PHASE I: Use the properties of the 1.1 oz/sq. yd. nylon as a reference to develop novel fibers and innovative manufacturing technologies to fabricate a light weight and low permeability flexible fabric for the construction of flexible model parachute canopies. As a minimum, the areal density and the air permeability of the new fabric should be four times less than those of the 1.1 oz/sq. yd. nylon. Examine the flexibility and other relevant scaling properties of the fabric and compare them with those of the full-scale nylon. Construct a small-scale parachute canopy with the new fabric and conduct preliminary tests to investigate its capability to simulate full-scale parachute performance.

PHASE II: Continue fabric development from Phase I and refine its properties for full-scale parachute simulation and scaling purposes Examine the fabric properties in details and compare them with those of the full-scale nylon. Construct a small-scale parachute with the new improved fabric and a same sized parachute with the full-scale nylon. Conduct wind tunnel tests on the two small-scale parachutes. Examine and compare their opening characteristics. Obtain full-scale parachute opening data and compare them with the small-scale parachute constructed with the new fabric in light of the scaling laws from the published literature. Evaluate and refine the scaling laws. Verify and establish scaling laws for full-scale parachute performance simulation and prediction.

PHASE III: Light weight fabrics are used extensively commercially in the area of industrial filters, medical hygiene, clothing, etc. In addition to making parachute models, light weight fabrics can also be used to make model tents for wind load study, kites, model airships, etc. There are a variety of dual-use applications that a Phase III can purse.

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KEYWORDS: Nonwoven fabrics, nanofibers, light weight fabrics, scaled model parachutes, and parachute performance simulation

A06-184 TITLE: Agent Indicating, Decontaminable, Barrier Material for Protection Against Chemical and Biological Warfare Agents

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Improve existing lightweight, flexible, flame resistant, chemical biological (CB) textile barrier materials by incorporating visible detection and self-decontamination into the material. Detection would be an interior color change that indicates chemical agent levels greater than acceptable concentration control levels (CCL). This improved CB barrier and indicator material would be used as skin material in military shelters.

DESCRIPTION: Current shelter CB materials provide barrier protection to Soldiers from CB warfare agents, but do not include a self-decontaminating and CB detection indicator features. Some reactive smart textiles use CB agents as the catalyst for self-decontamination while the chemical reaction for decontamination creates a barrier against the CB agents. If incorporated into shelter materials these smart textiles could be used to exhibit a visible warning when the barrier is compromised. 1. It may be possible to incorporate a color change into the decontamination reaction, thus indicating that the barrier is self-decontaminating due to dangerous agent concentrations. The shelters will be used during military operations and therefore it is not desirable to produce an audible or lit visual indicator as an audible or lit visual indicator warning could compromise mission operations. As a result, it would be desirable to exhibit this reaction via a noticeable color change even for the colorblind. In addition, the indicator should continue to function for the duration of unacceptable agent concentrations. A self-decontaminating material by nature should be reusable since the chemical reaction taking place rids the material of any agent residue. The material being used for this application must already be proven CB barrier materials. CB agents can infiltrate a collectively protected system for a number of reasons, including a drop in overpressure due to the ingress and egress of personnel, spent filter(s), or a breach in the barrier material. Because “on target attacks produce immediate casualties by contaminating troops and equipment” 2. It is pertinent that collective protection inhabitants are immediately made aware of a compromise of the toxic-free area.

Currently fielded systems detect the presence of CB agents above predetermined acceptable levels in the field. These CB agent detectors consist of indicator paper, test kits, and monitors. Detector paper and test kits are point-sampling methods that react with an agent present at a specific spot. Detection kits, such as M256A1, are very time consuming detection methods; they have separate techniques for sampling vapor and liquid. In fact the Army Fact File states that “By following the directions on the foil packets or in the instruction booklet, a Soldier can conduct a complete test with the liquid-sensitive M8 paper and the vapor-sensitive sampler-detector in approximately 20 minutes”. 3. This is unacceptable in the field environment. Automated chemical agent detection systems including the Joint Chemical Agent Detector (JCAD) offer “portable monitoring and small point chemical agent detector for aircraft, shipboard, and individual soldier protection” 4. and the Automatic Chemical Agent Alarm (ACADA) offer point sampling that is either mobile or at a fixed site, 5. These types of detectors are significantly impacted by placement, weather, and the tactical situation. The ACADA can run on either battery or AC power and the JCAD is a battery operated detector. Both the detectors are seen as point detectors and cannot sample a large scale area, such as a shelter. The battery operation and power supply requirements add logistical burdens to the system. Stand-off detectors are placed a distance from Soldiers and only provide detection for the fixed site. Another downfall to the detectors is the health concern of radiation, U.S. Air Force reports that the currently fielded Chemical Agent

Monitor (CAM), Improved Chemical Agent Monitor (ICAM) and ACADA do emit radiation. M8A1 detectors emit a higher amount of radiation and are thus restricted in their storage techniques. 6

Sandia National Laboratories has developed a color change coating or "nanoskin." The color change coating is "sensitive to the composition of chemicals hitting the structure" 7 by using the polymers nanostructure to detect a change in environment. This or a similar capability can be designed and/or optimized to integrate into a self-decontaminating CB barrier material for collective protection shelter systems. The color change indication, on the interior of the tent, should be in real-time and have the ability to be seen in low light. This technology would benefit the warfighter by giving immediate notification of the danger and therefore allowing the Soldiers to take rapid action in response to a CB attack. This technology could also replace the currently fielded Nuclear, Biological, Chemical (NBC) protective covers, indicating the exposure of critical food, water supplies, and equipment to hazardous agent. The material must be able to protect against mustard (HD) and the nerve agent, sarin (GB). An optimal material will protect against these agents, as well as, other nerve agents soman (GD) and VX. It is not a requirement for the material to indicate the type of agent that has compromised the barrier, only that the barrier has been compromised.

The objective of this effort shall be to combine barrier material, detection technologies, and self-decontaminating features into a reusable CB barrier material that will indicate the presence of CB agents through a visible contrasting color change. The material must pass Test Operation Procedure (TOP) 8-2-501 with Dynamic Diffusion method.8 The material would pass the protection levels specified and show the visible color change in testing. The material must be rugged and durable enough to withstand environmental loading, rough handling, and folding but also be lightweight in order to reduce the logistical burden of the shelter system. The material must be capable of protecting against CB agents for up to 72 hours but also have tear strength of 54 lbs and be abrasion resistant. 9

PHASE I: An overall feasibility study will be conducted to evaluate proof of CB self-decontaminating barrier material and color change technologies, The durability, reactivity, reusability, and logistics, such as upkeep and maintenance, will be investigated for the applicable CB barrier materials. Proven proper substrate barrier and textile materials will be used and indicator (color change) technology will be studied. Potential designs will be created for the overall material, and a laboratory study conducted to evaluate its performance and applicability. Demonstrate, through experimentation, the feasibility of paring the indicator technology and the proven CB barrier materials into a collective protection shelter fabric.

PHASE II: The material used in Phase I will be further optimized for characteristics such as durability and fabrication, as well as integrated into a full-scale collective protection tent system. Fabrication costs must be kept to a minimum and should not exceed $65.00/yard . Means by which the material can be made into a full scale prototype will be assessed. The seaming and/or welding of seams of the material will be explored, tested and optimized. A final full system demonstration will be made of the material and fitted to current tentage systems. In addition, an investigation of potential alternative applications should be conducted in conjunction with a market assessment.

PHASE III: There are no other current technologies that apply indicator technology to a self decontaminating CB barrier. This technology could also be integrated into military individual protection equipment. The material would provide real-time indication of a hazardous environment, enabling the Soldier to seek additional protection equipment. Proposed material could be introduced into the civilian marketplace along with current civilian CB barrier technologies. This application could be used in both toxic and non-toxic sensing of gases and/or liquids. For example, the barrier material could be integrated into rapid response and homeland defense and homeland security protection systems, providing real-time warning of a hazardous environment. Incorporation to protective suits for individuals would be highly likely. The material could possibly be integrated into liners for landfills and other environmental barrier applications. Also, it could be used to make hazardous or medical waste bags. There are many applications of this material to the medical field such as hospitals, doctors' offices and other places where sterile environments are needed and notification of a compromised environment would be beneficial. There is a potential application to fields where air purity is required and can be compromised such as refrigeration, air conditioning, furnaces, etc. Applications to the home would include countertops, cookware and flatware that would identify to a user the presence of bacteria. Possibly the material could be integrated into carbon monoxide indicators. The material could indicate leakage of chemicals or other hazardous materials in transportation, storage and manufacturing processes.

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KEYWORDS: Detection, Barrier Material, Chemical and Biological Protection, Indicator, Self Decontaminating, Reactive Materials

A06-185 TITLE: Wall Interrogator

TECHNOLOGY AREAS: Electronics, Human Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and demonstrate a portable device capable of scanning walls to identify the internal structural components, such as imbedded re-bar, to locate the optimum breach point, in addition to detecting any "near-field" objects or structures that lie beyond the wall; e.g. people, doorways, etc.

Technical Parameters:

- Maximum weight of 35 pounds (to be 1-man portable)
- Power supply requirements compatible with one or more of the Army¡¦s currently fielded Power Supplies
- Robust & Fieldable
- Capable of interrogating 8-inch thick, concrete walls
- Capable of detecting / identifying imbedded materials; e.g. intersecting walls, re-bar, piping, electrical conduit, voids, etc.

DESCRIPTION: The Wall Interrogator is envisioned as a 1st Generation, portable sensing device that utilizes radar technologies for the gathering of target intelligence. The ability to detect beyond-the-wall or ¡§near-field¡¨ objects would be essential; as well as provide the User with the capability of recording information for post-operations playback.

Technology of Interest: Lawrence Livermore National Laboratory (LLNL) has been developing the technologies for the Ultra Wide Bandwidth (UWB) radar and Micropower Impulse Radar (MIR). The innovative R&D lies in tailoring and ultimately combining these two technologies to develop a hybrid device that is one-man portable and suitable for fielding.

Neither the UWB radar or the MIR technology is solely capable of accurately identifying the range of components of interest to wall breachers. In addition, neither technology is currently robust enough or optimized for application in hostile MOUT scenarios. The technical challenge resides in accurately and reliably scanning a wall to determine structural composition, density variations, and intersecting walls; providing breachers intelligence as to what lies behind the wall (i.e. people).

Army Subject Matter Experts (SMEs) have identified both UWB radar and MIR technologies as leading contenders for Wall Interrogator-like applications. Optimized for MOUT wall scanning applications and tailored to accurately detect the materials of interest to breachers, the synergy of these two scanning approaches should produce target wall data that will enhance overall wall breaching effectiveness, minimize undesireable effects and improve soldier survivability.

PHASE I: Identify & evaluate suitable technologies and approaches. Design a device technically capable of meeting the primary objectives against the targets identified.

PHASE II: Develop & demo a prototype Wall Interrogator device capable of gathering usable data.

Current State-of-the-Art (SOTA): Army "wall breachers" currently have no dedicated, reliable resource for gathering target (wall) data and may therefore be forced to pass-over desirable targets. Structural uncertainty and the possibility of unforeseen negative collateral effects to either non-combatants or surrounding structures are common reasons. However, once given a mission, breachers will ultilize any possible resource to gather target data. In an active hostile environment resources can include UA/UGVs, local residents, prisoners, and Recon Teams.

DUAL USE APPLICATIONS: The Wall Interrogator device could also benefit police, First Responders, fire & rescue, and have potential Homeland Security applications. 2nd Gen devices could provide detection of buried mines & IEDs and possible 3-Dimensional mapping of buildings and structures.

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http://www.llnl.gov/str/September04/Azevedo.html

http://www.llnl.gov/str/pdfs/01_96.2.pdf

KEYWORDS: 8-inch reinforced concrete wall; Ultra Wide Bandwidth (UWB) radar; Micropower Impulse Radar (MIR); Detection / Identification of imbedded materials; Intersecting walls; Rebar

A06-186 TITLE: Single Action Wall (SAW) Breecher

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Demonstrate a man-portable wall breaching kit/system capable of cleanly breaching an 8-in concrete wall, double reinforced with imbedded rebar, in a relatively simple and direct operation.

Technical Parameters:

*Create a man-sized hole (39" dia. -or- 30"x 50") in a double reinforced 8-in concrete wall
*Clear the concrete and rebar in a simple 1-step operation
*Produce no collateral damage; i.e. Avoid causing total wall failure
*Weigh no more than 35 pounds
*Robust / Fieldable
*1-man portable
*Command-detonation capable
Note: The key challenge is in adequately clearing the imbedded rebar.

DESCRIPTION: The SAW Breacher is envisioned as a man-portable, wall breaching system utilizing a hybrid shaped charge warhead capable of creating (in a 1-step operation) a man-size wall entry point; i.e. (39" dia. -or- 30"x 50").

Technology of Interest: The technology of interest currently resides in short-standoff, linear shaped charge warhead designs utilizing liner materials optimized for short-standoff penetration. Advanced shaped charge liner geometries utilizing non-conventional liner materials enhanced with linear warhead initiation techniques appear to have the best potential for advancing the SOTA. Past designs utilizing conventional liner geometries, materials and single-point initiation have proven ineffective.

Technical Risk: The technical risk is 3-fold; i.e.,
1. Identifying a short-standoff linear warhead liner material and linear geometry capable of retaining enough jet tip velocity to cleanly defeat the embedded rebar.
2. Optimizing warhead performance thru the introduction of multi-point initiation techniques.
3. Designing a fieldable device capable of clearing a 39" Ø (or 30"x 50") hole in a 1-step operation.

PHASE I: Identify & evaluate suitable technologies and approaches. Design a device technically feasible and capable of meeting the primary objectives against the identified target.

PHASE II: Develop & demonstrate a prototype wall breaching system capable of breaching re-bar enforced walls in a single action.

Current State-of-the-Art (SOTA): The current SOTA in tactical military wall breaching centers on the Army's longstanding M112 Composition C4 Explosive Demolition Block. These explosive blocks, each containing 1.25 pounds of C4, can be utilized in various customized configurations or employed as a pre-configured M183 satchel charge.

The M183 satchel charge contains 16 individual M112 blocks, detonators and blasting cord and comes with its own canvass carrying satchel. Securing the M112 blocks or M183 satchel charge to a target wall is done manually and typically relies on simple devices known as "prop sticks" to hold the charges in place. Although these charges are quite powerful and capable of breaching concrete walls, they are ineffective against imbedded rebar. In addition, due to the extensive blast overpressure and debris produced at detonation, friendly forces must take cover at significant stand-off distances before detonating the charge.

The current wall breaching approach is a 3-step process which involves a Soldier emplacing a demolition charge against the target wall, detonation of the explosive charge, and finally the Soldier returning to the breach location to cut the exposed re-bar.

Note: The current process may require up to 32 re-bar cuts per breaching operation and unavoidably exposes the Soldier to potential hostile fire or other retaliation. Defeating the imbedded rebar is a key challenge.

A 1-step SAW Breacher system would simplify wall breaching operations, reduce a Soldier’s exposure time, enhance Soldier survivability, and improve OPTEMP.

A refined SAW Breacher system could possibly offer scalable effects to minimize collateral damage when employed against lesser targets and possibly utilize Robotics to remotely emplace and detonate the wall-breaching charge.

DUAL USE APPLICATIONS: SAW Breacher technology has application to SOCOM Operations; Commercial mining operations; Civilian rescue & recovery operations; and benefits to law enforcement and First Responders.

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KEYWORDS: wall-breaching, linear shaped charge, re-bar cutting, command detonation

A06-187 TITLE: <u>Continuous Power Assurance for Rotorcraft</u>

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: The objective of this SBIR is to develop accurate methods for on-board continuous power assurance of turboshaft engines in Army rotorcraft. Experience in both Afghanistan and Iraq has shown the need for accurate real-time assessment of engine performance and the ability to make immediate aircraft mission decisions based on this knowledge. A large percentage of engine related mishaps can be attributed to power management. The highest removal cause for engines is low power. Manual procedures are currently used to trend engine performance on a daily basis (Health Indicator Test, Power Assurance Check). In-flight checks for Desert Operations have been developed but similarly are an indicator of trends in performance, not actual engine performance. Procedures to determine actual performance (Maximum Power Check, Power Assurance Test) require dedicated high altitude and airspeed flight and are only done when an engine fails a HIT check or significant maintenance is performed. These tests produce a torque factor which is a ratio of the engine torque available to the nominal torque defined by the engine specification. The torque factor can then be used to estimate aircraft performance such as the ability to hover at altitude and payload capability. More accurate methods that continuously provide an indication of the power available would reduce aircraft mishaps and aid in mission and maintenance planning.

Turbine engine performance modeling and gas path analysis techniques exist but have not been applied such that real-time performance could be assessed. These techniques typically use sensor information that can only be obtained in a test cell environment. Current models are computationally intensive and would be a challenge to host on aircraft processors.

DESCRIPTION: This effort will develop improved methodologies and algorithms for the measurement and prediction of turboshaft engine performance in real-time onboard the aircraft. The effort should address measurement of performance at part power with projection to the engines maximum capability. Compensation for factors that lead to errors or scatter in the prediction shall be considered. The effects of varying performance degradation on the compressor, combustor and turbine sections should be addressed. Differences in turboshaft engine types, configuration, sensor packages and aircraft capabilities should be evaluated. Implementation issues such as data capture, processing and format for display to the pilot should be addressed. Additional aircraft hardware and pilot burden should be minimized. Modeling of the installed engine degradation and integration with existing aircraft systems is desired.

PHASE I: Phase I of the effort will develop and validate the proposed technology. Phase I will develop the technology sufficiently to prove viability and confirm the accuracy of the power predictions. The use of recorded test cell or aircraft data is desired. The source of this data as well as any engine or aircraft models should be identified in the Phase I proposal. A roadmap for implementation should be defined under this phase.

PHASE II: Phase II will develop the Phase I technology into a fully functional prototype. The system will be tested to assess the accuracy and repeatability.

PHASE III DUAL USE APPLICATIONS: This technology could be used for any rotorcraft. Commercial operators as well as other military services could use the technology developed to better manage the aircraft engines, aid mission planning and enhance aircraft safety. This technology could be integrated into aircraft through engine control units, avionics packages or aircraft monitoring systems.

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KEYWORDS: Power Assurance, Turboshaft Engine, Prognostics

A06-188 TITLE: Enhancing Computer Generated Forces (CGFs) for Air Traffic Control Interaction

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Research the feasibility of developing Computer Generated Forces (CGFs) that can interact with air traffic controllers in joint military simulation environments in the Defense Technology area of Information Systems Technology, specifically in the area of Modeling & Simulation Technology, and the Technology area of Battlespace Environments. The research should encompass analysis of current CGF technologies and interaction protocols. This effort should investigate new approaches to CGF interactions with air traffic control and: 1) determine what approach is appropriate given various situations occurring in the field and 2) establish a technical road map for developing appropriate technologies and protocols to allow for seamless, efficient, and effective interaction. Phase I will consist of feasibility concept researched from current work done in our labs as well as work done outside of the Defense arena, specifically in the commercial aviation world. Phase II will consist of a prototype demonstration of the information found during the feasibility/research study of Phase I. Phase II will also continue the research and development of this prototype with emphasis on integration with current Modeling and Simulations assets and experiments such as the ongoing Joint Aviation Manned Unmanned System (JAMUS) experiments conducted here at Systems Simulations & Development Directorate.

DESCRIPTION: The Army has begun to employ automated forces in simulation environments, either as fully autonomous entities or as wingmen to human pilots in immersive flight simulators. Autonomous agents in simulation have been shown to be effective in reducing manpower costs in terms of the number of human operators required to run an exercise. However, there are still numerous tasks that require operator-level interaction through a simulation's native user interface for fine-grained control of aircraft. One such task is detailed, doctrinally correct behavior in terminal areas (takeoff and landing zones, Forward Arming and Refueling Points) or other fine-grained control of aircraft during flight. Where air traffic control is played in simulation, it is often up to a human operator to interpret messages from an air traffic controller and translate those messages into entity-level commands.

This topic is concerned with the feasibility of autonomous air entities (fixed or rotary wing) to be managed/constrained in a simulation environment by human or simulated managers with doctrinally correct commands. This will explore the feasibility to obviate the need for an intervening human operator and to establish to what extent a human operator is needed for airspace management functions in a simulation environment. Can ATC functions be autonomously implemented and simulated in a battlespace and what is the optimal degree of autonomy to do so?

The ideal CGF system would be able to interact with a human or synthetic controller transparently at varying levels of autonomy and to automate actions that respond to approved airspace coordination measures. This could also include simulating dynamic retasking coordination and communication sequences. Phase I of this topic will research these ideas and determine there feasibility in the specific technology areas of Battlespace Environments as well as Information Systems Technology which include Decision-making; Information Assurance; Seamless Communication; Modeling & Simulation; Computing and Software Technology. State of the art work in the area of CGF design and implementation as been done in the past and continues in the SSDD labs in these Technology areas in conjunction with past experiments. These experiments include the Rapid Force Protection Initiative (RFPI), Full System Simulation 1 (FSS-1), FSS-2, FSS-3 (also known as First Application), Joint Aviation Manned Unmanned System I (JAMUS I), JAMUS II, and pre-work for JAMUS 2006. Also, past and current Crew Station Working Groups (CSWG), and Early User Demonstration type experiments will help to guide this Phase I feasibility study and the Phase II prototype demonstration by giving practical examples of the type of CGF that have been used in the past and the deficiencies they presented. These past and on-going experiments as well as the Modeling Architecture Technology, Research, and EXperimentation (MATREX) program and for Future Combat System (FCS) requirements will define and establish the technical parameters that will be the foundation for this technology of interest area of CGF, specifically in the area of Airspace Management in a battlefield context.

In controller-intensive applications or environments, controllers are typically manually engaged in managing the airspace. Enabling controllers, human or synthetic, to interact with automated entities requires a number of capabilities on the part of the automated entity, such as the ability to interact with the controller using correct verbiage, and an ability to execute proper maneuvers and give instructions in that environment. Most CGF systems today do not have capabilities for either, and those that do are very limited in their interactions with controllers. Often this ability is simply omitted in simulations, forcing each aircraft to fend for itself. If not left out of an exercise totally, the automated entity has to be manually directed by human operators. Without a system in place for automating these aspects of the virtual airspace, the simulation will lack full experimentation capabilities. This topic will investigate the inclusion or exclusion of Army Airspace Command & Control (A2C2) in tactical experiments, as well as integrating Tactical Airspace Integration System (TAIS) into a functional model for experimentation in future airspace concepts for Future Combat System (FCS), networked fires deconfliction and future Unmanned Aerial Vehicle (UAV) capabilities.

We are searching for a method to pull new technology and legacy systems together to research and explore concepts for autonomous entities that are capable of interacting at high levels of fidelity with human or synthetic controllers in simulated battle spaces, capable of running at an acceptable level of performance for both concept evaluation and system performance studies.

Technology to be used included in this study should consist of, but not limited to, voice recognition and response, cognitive decision aids, computer-generated forces, and real-time distributed simulation. All these technologies fall in the Defense Technology Area of either Information System Technology or Battlespace Environments. This Phase I SBIR seeks to gain firm analytical answers for the level of effort and cost for developing such a system. Past studies and exercises such as Manned-Unmanned (MUM) experiment, RFPI, JAMUS, FSS1, FSS 2, and FSS 3 (First App), will be of value when investigating this technology. It will allow us to see how far the technology has matured and where we can take it to enhance CGFs for Air Traffic Control Interaction.

The benefits are numerous, including: filling a void in battlefield aviation and weapon simulations in the area of battlefield airspace management, reducing air space confliction, serving as a test bed for future pilot-controller interaction functions, and reducing or possibly eliminating the need for a man-in-the-loop. As stated before, this type of interaction has historically been omitted in simulations for many reasons with minimal effect; however, as ATC functions migrate from tower operations toward comprehensive Joint tactical airspace management, there will be many opportunities for more advanced CGFs for Air Traffic Control Interaction to be integrated into distributed simulation exercises in the future.

This technology will filter into the commercial world for all flight simulations used around the world in all types of aircraft and across all military branches of service. This will also leverage the multi-purpose technologies developed within government facilities.

PHASE I:
1. Investigate requirements for autonomous air entities to perform doctrinally correct behavior under the control of an air traffic controller. Document the feasibility of such requirements. This research is to be based on the technology areas of Information Systems Technology and Battlespace Environments.
2. Develop a feasibility plan for implementing communication between the automated entity and a human or synthetic ATC in the designated test airspace. Much value is to be gained by using past experiments as outlined in the main topic such as the Rapid Force Protection Initiative (RFPI), Full System Simulation 1 (FSS-1), FSS-2, FSS-3 (also known as First Application), JAMUS I, JAMUS II, and pre-work for JAMUS 2006.
3. Evaluate the ability and feasibility to tailor multiple aviation applications, such as: flight dynamics, human factor study analysis, and various simulation data sets.
4. Research the baseline feasibility of enhancing existing autonomous entity systems to be controlled by autonomous or human controllers using doctrinal ATC communication.

PHASE II:
1. Provide a prototype system demonstration which has been researched and determined to provide a solution to meet the goals and objectives set forth in Phase I and the following four parts of Phase II. This prototype system will be expected to participate in future JAMUS experiments as well as other distributed excercises that will follow.
2. Use the knowledge gained from the research and study in Phase I to propose new and inventive approaches to automating doctrinally correct autonomous entity behavior under the control of an air traffic controller.
2. Define data requirements to pass necessary information between the automated entity and human or simulated air traffic controllers.
3. Determine a simulation framework that is tailorable to various tactical aviation applications. The tailorability must include the ability to modify the following aspects of the flight simulator: flight dynamics, voice recognition command sets, simulation interoperability data sets, and mission planning functionality.
4. Collect user and Government representative inputs concerning improvements, problems, or concerns.

PHASE III: Explore additional applications of this technology, such as in tactics development, future combat systems, training, and cognitive decision aids for military and industry.

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1) Taylor, G., Miller, J., Maddox, J. (2005) “Automating Simulation-based Air Traffic Control.” Proceedings of Interservice/Industry Training, Simulation, & Education Conference. Orlando, FL: NTSA.
2) Air traffic control students receive new simulator
http://www-tradoc.army.mil/pao/TNSarchives/August03/newATCsimulator.htm
3) Pew, R. W. and Mavor, A. S. eds., Modeling Human and Organizational Behavior, National Academy Press, Washington, DC, 1998.

KEYWORDS: Air Traffic Control, ATC, Battlespace Environments, Information System Technology, Decision making Information Assurance, Modeling & Simulation Technology, computing and software technology, voice recognition, cognitive decision aids, computer generated forces, real-time distributed simulation, UAV, rotor craft, fixed wing, JAMUS, FSS-1, FSS-2, FSS-3, First App, RFPI, MUM, Full System Simulation, Modeling Architecture Technology, Research, and Experimentation, MATREX, Future Combat System, FCS, ASM, Airspace management, Joint Aviation Manned Unmanned System

A06-189 TITLE: Reflective Cognitive Agents Supporting Faster than Real-time Course Of Action Analysis (COAA)

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: To demonstrate the use of Software Agent (SA) technology to proactively coordinate the integration of live operational data sources into Modeling & Simulation (M&S) capabilities running on High Performance Computing (HPC) platforms in order to address real-life Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) effects challenges in support of faster than real-time Course Of Action Analysis (COAA).

DESCRIPTION: Advances in technologies such as HPC and Grid Computing have made it possible to produce faster than real-time M&S capabilities at levels of fidelity, scale, and speed that were previously unattainable. The challenge today for military and commercial simulation applications is to be able to effectively and efficiently apply live operational data drawn from a myriad of disparate sources of persistent and dynamic information into the existing validated HPC-based M&S capabilities.

The availability of new live data input resources that could be useful and relevant in existing M&S applications are rapidly outpacing their ability to be effectively and efficiently exploited. Many of these new data source capabilities are often comprised of data schemas that are incompatible or inconsistent with existing legacy data transaction methodologies, which can impede their ability to be effectively utilized. Further, advances in HPC technologies have made it possible for simulation applications to process much greater numbers of individual elements, which can also contribute to the overall complexity of the task.

The field of Agent-Supported Simulation has shown promise by utilizing SA technologies to address the complex tasks associated with managing disparate data inputs into HPC M&S applications and multi-agent systems (such as those used to perform complex predictions that must be both relevant and actionable).

Agent-Supported Simulation is defined as: The use of agent technology to support simulation activities; they comprise front-end and back-end activities of a modeling and simulation environment, agent-supported validation and verification, as well as agent-supported program generation, program integration, and program understanding.

One example from the field of Software Agent (SA) technology that is germane to the objectives of Agent-Supported Simulation is the Reflective Cognitive Agent (RCA). A RCA is a type of software agent which is aware of its own ontology and is capable of dynamically adapting its composition based upon its specific task requirements, and of collaborating with other agents.   This adaptive behavior is a highly desirable capability because it presents an approach for dynamically learning from the environment and self-adapting in order to autonomously complete a specific mission objective. RCA technology can enable newly established data sources to be applied with existing M&S applications in ways that are faster and more reliable than traditional data integration techniques.

The objective of this SBIR topic is to develop, demonstrate, and ultimately transition a viable SA and RCA technology approach that can leverage HPC M&S capabilities with live operational dynamic data sources in order to execute faster than real-time predictions of mobile communication behaviors and effects, and to apply these predictions in the context of supporting complex COAA decision making.

The technology described within this topic is soliciting Research & Development - i.e., projects involving a degree of technical risk- rather than procurement.

PHASE I: The deliverable of Phase I will be a technical feasibility study that will define the offerer’s approach for exploring, investigating, and validating the viability of using SA and Reflective Cognitive Agent technologies to address the scope of the prototype described in 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 a recommended 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 mobile wireless communications network planning and awareness tasks required to support the goal of real-time COAA capabilities.

The Phase II prototype will support completing complex COAA tasks such as: prediction of loss of connectivity of mobile network elements based upon conditions, or route of travel; prediction of regional connectivity based upon positioning of network resources; establishing or restoring connectivity to nodes or regions through alternate paths, repositioning, or addition of network resources. The prototype will leverage available sources of information, M&S resources, and SAs such as: Predictive models and simulations of network communication RF propagation effects; Predictive weather; physical terrain features; network ontology; network traffic status; real-time network asset location, mission context information, and C4ISR information dissemination architectures. The solution will include an RCA capability that will be able to identify the necessary relevant resources and modify itself to incorporate additional components such as SAs or data connectors that would be required to complete its mission objectives

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 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 software (both executable and full 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. Some potential commercial market applications for this innovation include the cellular communications and transportation industries, and homeland defense. 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) "Exploring Agent-Supported Simulation Brokering On The Semantic Web: Foundations For A Dynamic Composability Approach", Levent Yilmaz and Tuncer I. Ören, Proceedings of the 2004 Winter Simulation Conference, 2004, (http://www.informs-cs.org/wsc04papers/095.pdf).
2) "Agent-Directed Simulation Challenges To Meet Defense And Civilian Requirements", Tuncer I. Ören, Proceedings of the 2000 Winter Simulation Conference, 2000, (http://www.informs-cs.org/wsc00papers/241.PDF)
3) "FireGrid: Integrated emergency response and fire safety engineering for the future built environment", Dr. Dave Berry, National eScience Centre, University of Edinburgh, May 2005, (http://www.see.ed.ac.uk/~firegrid/publications/FireGrid_AHM.pdf) .
4) "Coalition Agents Experiment (COAX) Technology Integration Experiment Document", AFRL Rome, AIAI, BBN, Boeing, CMU, Dartmouth, DSTL, DSTO, GITI, LM-ATL, Michigan, NRL, OBJS, Potomac Institute, QinetiQ, TTCP, UMD, USC/ISI, UT-Austin, UWF/IHMC, 24 Mar 2002. (http://www.aiai.ed.ac.uk/project/coax/doc/CoAX-Binni-Main-24mar02.pdf)
5) "Software Agents" http://en.wikipedia.org/wiki/Software_agent.

KEYWORDS: Software Agents, Cognitive Agents, High Performance Computing Systems, Modeling and Simulation, decision support, command and control, Agent-Directed Simulation, Agent-Supported Simulation, supercomputing

A06-190 TITLE: HMMWV Towable Load Following 100 kW Power Unit

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: To optimize the combat effectiveness of Future Forces through the development of an advanced highly power dense, load following 100 kW (nominal) power system that is capable of being towed by a standard High Mobility Multi-Purpose Wheeled Vehicle (HMMWV). The resulting power system shall enable strategic responsiveness and enhance core war fighting capabilities of various Future Combat System (FCS) platforms for Future Force and GWOT applications requiring 80 - 120 kW of power. FCS platforms include:

• Chemical Protection systems and equipment (Chemical and Biological Protective Shelter (CBPS), CP Field Hospitals, and CP DEPMEDS systems);
• Global War On Terror (GWOT) activities: Operation Enduring Freedom, Operation Iraqi Freedom, and Horn of Africa;
• Force Provider – self enclosed camps; and
• Tactical Operating Centers (TOC) – Brigade Level and above.

DESCRIPTION: The Army's vision is to develop lightweight FCS systems that can deploy quickly, anywhere in the world. However, FCS requirements for increased OPTEMPO, modular agile units, improved strategic responsiveness, and enhanced core war fighting capabilities place significant mobility demands on the capabilities of power systems and tactical vehicles. As a result, combat effectiveness of FCS platforms can be compromised. To improve combat effectiveness, new power system designs must be developed that improve mobility, increase power density, increase fuel efficiency, and support a wider range of loads.

Because Tactical Electric Power (TEP) sources are integral to all FSC platforms, the Army seeks to reduce the logistic burden of supported power systems. This reduction can be accomplished through the use of high speed, high frequency, and high-temperature power subsystems and components that lead to “operationally significant” reductions in fuel needs, weight, size and maintenance. Successful designs should improve mobility, deployability, and reliability; decrease theater footprint; and enable key operational capabilities throughout the battlespace by providing electricity to supported systems and managing power distribution across the force. (per TRADOC Force Operating Capability (FOC) 09-03 - Power and Energy)

The focus of this effort will be to design and fabricate critical subsystems leading to a signature suppressed, load following power system capable of providing a continuous output of 80 to 120 kW, operating on JP-8 fuel, and of being towed by a standard HMMWV.

In order to achieve a higher power density system that can effectively provide variable power output, follow load and efficiently convert JP-8 fuel to electricity, innovative approaches to integrated multifunctional power and energy storage technologies and 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: Identify/specify proposed emerging power conversion and generation technologies and energy storage technologies that will yield advanced power components and subsystems for integration into a highly power dense, load following 100 kW (nominal) power system. Technology areas of interest include advanced/alternative atomization/vaporization techniques and performance enhancing materials; JP-8 fuel burning engines, alternators, variable speed power electronic controls; and energy storage devices. Selected components/subsystems shall be electrically compatible with aforementioned tactical applications. Technology drivers considered shall be size, weight, and cost.

Components and subsystems selected shall enable the following basic design requirements for the desired power source operating at full rated load:

• Fuel: JP-8 fuel burning.
• Output: providing 80 to 120 kW of continuous power output up to 4000

feet, 95oF (1219 m, 35 oC) with no degradation.
• Environment: operating at sea level with no degradation of power output within a temperature range from - 32 oC (- 25 oF) to + 60 oC (+140 oF) at any possible relative humidity within this range.
• Fuel Consumption: reduce fuel consumption from a system perspective (generator set, trailer, and towing vehicle).
• Power Quality: per MIL-STD-1332B.
• Weight: reduce by 50 % (baseline 100 kW TQG = 5,900 lbs or 2,676 kg).

Develop conceptual power component and subsystem designs compatible for integration into the HMMWV towable high power density 100 kW power system. The designs should include the following elements:

a. Narrative and graphical depiction of the design
b. Projected physical attributes (size, weight…)
c. HMMWV Towability Analysis (trailer, payload limitations, towability limits…).

A decision model of selected components and subsystem 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 critical power components for development in Phase II and integration into an operational variable speed, load following power mule capable of providing a continuous output of 80 to 120 kW and operating on JP-8 fuel. Mule Component/Subsystem designs shall consider integration issues that allow towing by a standard HMMWV.

PHASE II: Component Fabrication/Integration of Mule/Testing: The component and subsystem designs from Phase I will be fabricated, 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 load following demonstration power system.

PHASE III: The results from the Phase II effort will afford the contractor the capability to provide industry an advanced state-of-the-art load following power source with increased power density and increased fuel efficiency that can support a wider range of loads. Potential commercial applications for a mobile higher power density system that consumes liquid fuel and that can effectively provide continuous, variable power output (80 to 120 kW), follow load and efficiently convert JP-8 fuel to electricity for either primary or backup power for emergency mobile hospitals, temporary field police stations and developing nations.

POTENTIAL COMMERCIAL APPLICATIONS: The results of this development effort will help to advance and broaden the design approaches of the next generation power families developed in support of GWOT applications, of rebuilding nations, supporting disaster relief activities and back up power systems for hospitals, hotels, grocery stores. The decision model approach used in phase I should be applied to commercial applications.

REFERENCES:
1) Pamphlet 525-66, Military Operations - Force Operating Capabilities
2) 10kW SICPS Auxiliary Power Unit (http://www.pm-mep.army.mil/technicaldata/10kwapu.htm).

KEYWORDS: optimized combat effectiveness, variable speed, load following 100 kW (nominal); HMMWV towable; enhanced strategic responsiveness

A06-191		TITLE: <u>Lightweight Mine-Protected Fasteners for Blast Protection Appliqués</u>

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: Model, design, develop and build fasteners for attachment of blast protection appliqués. The resultant type of fastener should be able to reliably withstand blast forces and pressures of an anti-vehicular mine blast which produces 40,000 N-s or greater impulse.

DESCRIPTION: Blast protection appliqués are used on tactical and combat ground vehicles as a method of deflecting or mitigating the effects of anti-vehicular mine blasts or Improvised Explosive Devices (IEDs). A critical component of these appliqués is the fastener method. The purpose of this topic is to investigate materials, models, simulations, and alternate designs for high performance fasteners for tactical vehicle blast protection appliqués that neither shear nor fragment during a 40,000 N-s or greater impulse.

PHASE I: Conduct a study to determine alternate materials for the current fastener(s) for the blast protection appliqué that would reduce or eliminate the effects of shear and fragmentation during an anti-vehicular blast event. Compare the alternate materials to the current material with regard to weight, availability, and cost. Model and simulate the current design under normal operating conditions as well as during an anti-vehicular blast impact. Develop an initial concept for an alternative fastening system or fastener that also addresses weight reduction, more efficient installation, reduction of shear failure and fragmentation, and cost.

PHASE II: Using results from Phase I, fabricate, test, and validate a prototype fastener design for an impulse resulting from an anti-vehicular blast event against a tactical vehicle. The design should reduce weight by 25-40% compared to typical fasteners, minimize shearing and fragmentation effects, and decrease the time to install the blast protection kit at a reasonable cost.

PHASE III: A lightweight high-performance fastener system would be beneficial to both the automotive and aerospace industries, due to increased use of innovative materials in both industries. Additional markets would include aftermarket automotive companies that offer specialty ballistic armor and blast protection products for civilian vehicles.

REFERENCES:
1. MIL-HDBK-60, "THREADED FASTENERS - TIGHTENING TO PROPER TENSION."
2. MIL-HDBK-17/2, "COMPOSITE MATERIALS HANDBOOK - VOLUME 2 POLYMER MATRIX COMPOSITES MATERIALS PROPERTIES
3. MIL-HDBK-17/3, "COMPOSITE MATERIALS HANDBOOK VOLUME 3. POLYMER MATRIX COMPOSITES MATERIALS USAGE, DESIGN, AND ANALYSIS"
All references found at: http://combatindex.com/mil_docs/mil_hdbk_index_01.html

KEYWORDS: High performance fastener, blast protection, appliqué, anti-vehicular mine, tactical vehicle, survivability

A06-192 TITLE: Innovative Impact Energy Absorber Appliqué

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop an energy absorbing kit for uparmored tactical vehicles using novel, lightweight, and more efficient materials and/or structures which would reduce the severity of impact leading to injury or death resulting from vehicle collisions, rollovers, or resultant secondary impact effects of mine blast or improvised explosive devices (IEDs).

DESCRIPTION: The armor level and thus the stiffness of various tactical vehicle body panels has increased significantly. As a result, there is a need for impact energy attenuating materials and structures for these body panels in order to make it possible to ensure significant reduction of the incidence of injury due to collisions between soldiers and these body panels.

Various solutions to this problem currently exist and are well known; materials or structures are sought that offer exceptional levels of impact protection but that, at the same time, contribute less weight per vehicle and require less space in order to accomplish the energy absorbing function.

PHASE I: Candidates should propose either a passive or active concept for tactical vehicle application. Phase I activities should include the development of the initially proposed concept, design and development of a bench scaled sample, and testing on the sample using the FMVSS 201U impact test. Candidate concepts should address material areal density, performance and energy absorbing efficiency, durability, manufacturable feasibility, and demonstrate product robustness using six-sigma methods.

PHASE II: Based on Phase I results, design, build, test and evaluate a vehicle level prototype system for tactical vehicle application. Demonstrate the prototype in accordance with the demo success criteria developed in Phase I. Testing will follow in-vehicle FMVSS 201U requirements. Required Phase II deliverables include a field-tested validated prototype.

PHASE III: An energy absorbing kit would be beneficial to both military and automotive industries, due to increased use of innovative lightweight materials, as well as the increased need for additional safety products. Additional markets would include development of improved military helmets, motorcycle helmets, bicycle helmets, athletic helmets, padding, automotive upper interiors and knee bolsters, sporting goods, and artificial playground surfaces.

REFERENCES:
1) Code of Federal Regulation Title 49 (Transportation) Chapter V (NHTSA, DOT) Part 571 - 201U, Upper Interior Head Impact Protection.
2) NHTSA, Laboratory Test Procedure for Federal Motor Vehicle Safety Standard 201U, Upper Interior Head Impact Protection
(TP-201U-01, 1998).
3) Lim, G. G., Chou, C. C., Patel, R. N., Shahab, S. A. and Patel, P. J., Estimating the Minimum Space to Meet Federal Interior Head
Impact Requirement", SAE Paper No. 950333, 1995.
4) Chou, C.C., et al, “Comparative Analysis of Different Energy Absorbing Materials for Interior Head Impact”, SAE Paper No. 950332, 1995.
5) Rychlewski, Helen A., Miller II, P. Michael, "A General Discussion on Interior Design Alternatives in Response to FMVSS 201U-Upper Interior Head Impact Protection", Proceedings of the International Body Engineering Conference (IBEC) ’98, Vol. 6, pg. 335, 1998
6) Gandhe, Gajanan V., Tusim, Martin H., “High Efficiency Energy Absorption Olefinic Foam”, SAE Technical Paper No. 1999-01-0296, 1999
7) Cormier, J., Brooks, R. “Design of Thermoformed Plastic Mechanical Energy Absorbers for FMVSS 201 Head Injury Applications”, 2001 Detroit Auto Interiors Show Conference Proceedings.

KEYWORDS: Energy management, Rollover, Rollover protection, Energy absorber, Impact attenuation, Occupant protection, Survivability, Blast protection, Crash protection, Tactical vehicle, HMMWV

A06-193 TITLE: Two-Phase Thermal Management Device Resistant to the Effects of Mechanical Vibration and Shock.

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop a two-phase thermal management device resistant to the effects of mechanical vibration and shock. The device must be applicable to electronics cooling and be able to integrate into a thermal bus design.

DESCRIPTION: Passive thermal management technologies have been identified as a potential solution for electronics thermal management issues in next generation ground vehicles. Historically this technology has been used by the aerospace industry. Due to the environment it was applied to, current devices were not designed to endure the various mechanical effects that will be experienced on ground vehicle applications.

An innovative solution is required to produce a two-phase thermal management device capable of enduring the mechanical vibration and shock they will be exposed to when used for combat vehicle applications.

Mechanical vibration is a very important design parameter to consider in ground vehicle design. Vibration levels vary from low to high severity during vehicle operation. The vibration characteristics, including frequency and amplitude, differ by mounting location. Power spectral density (PSD) information is required for the exact mounting location to ideally determine the influence of vibrations. The PSD provides the vibration energy as a function of frequency bands over the relevant range. De Vos et al reported vibration levels typical of automobiles ranging from 10 Grms on the engine to 3-5 Grms in the passenger compartment [1]. It is hypothesized that a vibration frequency exists within passive thermal devices that is based on the size of the evaporator pore. This leads to a disruption of the liquid-vapor interface (meniscus). Since the meniscus is a key to the maintenance of the capillary pressure any undesirable disruption of that surface would negatively impact performance.

The combat vehicle mechanical shock environment is divided into four classes: Basic,Gun Firing, Operational Ballistic and High Intensity. Shock impulses are not merely a magnitude but also a duration and frequency. The primary concern for vehicle developers is the durability of components and the design of mounting brackets. The shock values range from a basic shock of 30g @ a 11ms half sine wave to high intensity shock of 1200g @ a 1ms half sine wave. The operational shock determined for an automobile or truck is 20g @ 1.5 ms [2]. For a passive thermal device, mechanical shock may change the fluid distribution. Ku et al described the importance of fluid distribution on the initial start up behavior and ultimate operating characteristics of a loop heat pipe [3]. It is anticipated that short duration and less frequent shocks will not have significant impacts to the system. However, large, periodic shocks will displace fluid and may result in lasting changes.

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.

PHASE III: Next generation vehicles are a major research and development activity within the automotive industry. The development, demonstration, and integration of robust thermal management technologies into electric and hybrid-electric vehicles represent numerous technical challenges requiring innovative solutions which in turn can be directly applied in the military and private sectors.

REFERENCES:
1) De Vos, Glen W. and Helton, David E., "Migration of Powertrain Electronics to On-Engine and On-Transmission", SAE International, 400 Commonwealth Drive,Warrendale, PA 15096-0001, 1999-01-0159, 1999.
2) "Recommended Environmental Practices for Electronic Equipment Design-SAE J1211", Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001, J1211, 1999.
3) Ku, Jentung, Ottenstein, Laura, Kaya, Tarik, Rogers, Paul D., and Hoff, Craig J., "Testing of a Loop Heat Pipe Subjected to Variable Accelerating Forces: Part 1 Start-up", 30th International Conference on Environmental Systems, July 10-13, 2000, Toulouse, France.

KEYWORDS: two-phase, thermal management, electronics, mechanical shock, mechanical vibration, thermal bus

A06-194 TITLE: Complete Thermal Management Modeling Tool for System Integration of HVAC Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The objective is to create a rapid prototyping modeling tool capable of quickly and effectively designing military systems that can survive and perform efficiently in hot environments. This topic seeks to add a capability of rapid (heating, ventilation, air conditioning) HVAC design that does more than assume pristine lab conditions or use basic analysis principles. It seeks a new modeling capability that is easy to use, computes quickly, yet is robust enough to include the complete range of thermal environmental conditions an HVAC system may have to face and the impact of the component on the rest of the system. This tool would be capable of rapidly analyzing the effectiveness of thermal management (HVAC) systems in existing or concept vehicles and buildings. The tool will be capable of modeling fan-driven air flow in duct networks, fluid mixing in enclosures, natural and forced convection in ducts and enclosures, and generating transient thermal loads from the complete assortment of sources. This would include environmental (solar radiation, ground radiation, and convection) and on-board heat sources (propulsion systems, electronics systems, auxiliary power units, and personnel). The tool should be configured to enable rapid design trade studies early in the design process to solve crew comfort issues as well as overall thermal management issues.

DESCRIPTION: Military Vehicles are being subjected to extremely hot environments with ever-increasing on-board power dissipation. This leads to problems maintaining adequate crew comfort and effectiveness, equipment reliability, and potential thermal signature problems. The root cause of all these problems is an inadequate thermal management system design. Several options could be proposed to solve problems such as these, but finding the best solution during the design phase would typically require trade studies based on extensive CFD (Computational Fluid Dynamics) analyses, laborious thermal modeling of duct networks, application of transient thermal loads due both to equipment and changing environment, and doing so on an evolving vehicle design. The state of the art for Computer Aided Engineering (CAE) software that could address this problem would preclude doing a comprehensive analysis in a rapid manner.

Recent Army thermal analysis efforts have revealed a capability gap in the analysis toolbox. The Army desires an innovative modeling capability that allows for rapid analysis without loss of accuracy. Specifically, this capability or tool would be capable of analyzing the effectiveness of thermal management (heating, ventilation, air conditioning-HVAC) systems in existing or concept vehicles and buildings. The tool will be capable of rapidly modeling fan-driven air flow in duct networks, fluid mixing in enclosures, natural and forced convection in ducts and enclosures, and generating transient thermal loads from the complete assortment of sources. This would include full environmental (solar radiation, ground radiation, and convection) as well as on-board heat sources (propulsion systems, electronics systems, auxiliary power units, and personnel). The tool should be configured to enable rapid model set-up and modification and to support rapid analysis trade studies early in the design process for either legacy systems looking for a quick fix to current thermal concerns, systems going through Reset or Recap or entirely new systems looking for an optimum design. Of particular concern is the Future Combat System (FCS) program with an ever-increasing number of electronics modules proposed for the system which is creating both a power and thermal management crisis.

PHASE I: Research the needs, methods, and techniques used by HVAC system integrators, identifying modeling bottlenecks and areas where modeling capability is lacking. Create a prototype of an analysis tool directed toward HVAC system integration into vehicles and buildings. The prototype should demonstrate a model of fan-driven air flow through a duct network with flow division based on the flow impedance of the network; mixing of duct effluent with stagnant air in an enclosure; and convection between the air volume and the surrounding environment, both in the ducting system and the conditioned chamber. The prototype should demonstrate a software architecture that enables rapid model set-up and modification, to support rapid analysis in the early stages of the design process.

PHASE II: Develop the prototype into a commercial HVAC analysis tool. Investigate and incorporate methods to rapidly create models of fan-driven duct networks. Research the possibility of using surrogate CFD methods to model mixing and low speed flow in enclosures and ducts. Incorporate these methods into the tool to provide the ability to predict flow distributions in duct networks, predict the movement and mixing of air flowing into an enclosure, and calculate convection between the air and the surrounding environment. In addition, the tool should be able to predict the environmental heat load on the HVAC system due to external (weather and solar) and internal (on-board heat generation) sources. The tool should be flexible enough to enable trade studies of alternative concepts during the design cycle.

PHASE III: Thermal Modeling has proven to be an extremely successful commercial venture in past SBIRs. If successful, an innovation allowing rapid analysis of HVAC has application in many areas such as: the automotive and aerospace industry for the design of passenger compartments, in architecture for air-conditioning system integration with building design and wherever air-handling systems are required, and in the electronics industry for the design of air-cooled electronics enclosures. It would be useful for new vehicle designs as well as retrofits of systems in vehicles operating in more severe conditions than originally planned. In addition to vehicle design, the tool would be useful to military mission planners to evaluate vehicle performance under extreme conditions.

REFERENCES:
1) Salter, Margaret S. and Eakin, David E., Bradley Fighting Vehicle: Heat in the Driver’s Compartment, Research Product 2001-01, U.S. Army Research Institute for the Behavioral and Social Sciences, December 2000. http://www.hqda.army.mil/ari/pdf/rp2001-01.pdf
2) Edmund Sanders, "Heat can be withering enemy", (c) 2004, Los Angeles Times, August 11, 2004. www.nevadaappeal.com/apps/pbcs.dll/ article?AID=/20040811/NATIONWORLD/108110019

KEYWORDS: HVAC, thermal analysis, vehicle design, thermal management, duct flow, flow networks

A06-195 TITLE: Remote Control Improvised Explosive Device (RCIED) Low Band Jammer

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Develop a low band jammer that will only jam signals from low band Radio Controlled Improvised Explosive Devices (RCIED)'s while simultaneously allowing low frequency Blue Force Communications systems to operate. Develop actions that can be taken to mitigate the harmful effects of Counter Remote Control Improvised Explosive Device (RCIED) jammer operations to BLUE (Friendly) systems.

DESCRIPTION: Radio Controlled Improvised Explosive Devices (RCIED’s)continue to threaten US forces as they conduct overseas operations. RCIED's can employ relatively inexpensive low band radios which are readily available on the open market from several international vendors. The major objective is to produce a jammer system that can effectively deal with these proliferating low band radios which can pose an emerging asymmetric threat when used for RCIED's.

The jammer must operate between 0.5 to X MHz and have an instantaneous bandwidth across the frequency range. The dynamic range shall be greater than 90 decibels (dB) and have a resolution bandwidth of less then 1 KHz. The output power will depend on the power amplifier used but is typically 500 W or more. A minimum of four RCIED targets shall be simultaneously attacked and the jammer will employ the lockout and amplitude fratricide protection method. Jamming latency will be less than 1 millisecond. It is desired that jammer will use a TCP/IP networking protocol for communications with other remote command centers sas well as local operations with a laptop.

PHASE I: Develop a theoretical model to define the specifications and parameters for the low band RCIED jammer. Analyze the effectiveness of the jammer in different threat scenarios. Identify low band COTS power amplifiers suitable for use in the system. Identify suitable COTS antennas and the feasibility of using mobile low band antennas. Design and develop various fratricide protection techniques. Provide a report with a preliminary Technical

Specification which includes a Concept of Operations (CONOPS) and suggests viable fratricide protection methods. Formulate commercialization and technology insertion plan to prepare for Phase II.

PHASE II: Design, build and demonstrate a prototype low band RCIED jammer including the mechanical enclosures. Low band RCIED jammer tests should be conducted in an environment emulating the intended applications of the tuner. Generate a report showing the result and comparisons to the theoretical model along with any deviations from expectations.

PHASE III: The completion of this phase would result in a mature technology, which could be successfully applied to both military and commercial applications such as law enforcement and homeland defense.

REFERENCES:
1) Putman, C. A., S. S. Rappaport, and D. L. Schilling, "Tracking of Frequency-Hopped Spread Spectrum Signals in Adverse Environments," IEEE Transactions on Communication, Vol. COM-31, No. 955, August 1983
2) Hassan, A. A., W. E. and J. E. Hershey, "Frequency-Hopped Spread Spectrum in the Presence of a Follower Partial-Band Jammer", IEEE Transactions on Communication, Vol. 41, No. 7, July 1993 pp. 1125-1131
3) Torrieri, D. J., "Fundamental Limitations on Repeater Jamming of Frequency-Hopping Communications", IEEE Journal on Selected Areas of Communications, Vol SAC-7, No. 569, May 1989
4) Hassan, A. A., J. E. Hershey, and J. E. Schroeder, "On a Follower Tone-Jammer Countermeasure Technique," IEEE Transactions on Communication, Vol. 43, No. 2/3/4, Feb/Mar/April 1995, pp. 754-756.
5) Introduction to Communication Electronic Warfare Systems, chapter 7 Electronic Attack, by Richard A. Poisel.
6) HF Communication, A System Approach by Nicholas M.Maslin.
7) Morden Communications Jaming Principles and Techniques by Richard A. Poisel.
8) EW101, A First Course in Electronic Warfare, by Dave Adamy .

KEYWORDS: Electronic Warfare, Jammers, Fratricide Protection, Frequency Hopper Radios, Electronic Attack Systems

A06-196 TITLE: <u>High Power Ka/Ku Dual-Band mm-wave Power Amplifiers</u>

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To produce high power, single input and output, Ku/Ka (or Ka/Q) dual-band mm-wave integrated power amplifiers.

DESCRIPTION: A major cost driver in any communications system is the radio frequency (RF) power amplifier. This single component uses the greatest amount of power and space (due to required heat sinking) and generates the most heat. In most systems, it is a major cost driver and the major limiter of reliability. The current two power amplifier approach utilizes valuable space and increases dissipated heat; it is also heavy, and costly. A dual band power amplifier will reduce cost, improve integration, and reduce weight and overall size leading to greater mobility.

The major challenge facing power amplifier designers is to obtain an optimum match for RF power delivery. For semiconductor devices, it is difficult (except for small devices with low output power) to match for optimum power delivery over a wide frequency band. Thus power amplifier designers rarely produce multi-band power amplifiers. This is particularly true for high power (greater than 1 watt) amplifiers. There are several techniques for improving the bandwidth of amplifiers (e.g. distributed amplification techniques); however, most of them reduce the output power or lead to combining inefficiencies.

The above challenges are further exacerbated at mm-wave frequencies. So far antenna systems utilizing the Ku, Ka, and Q-band frequencies have resorted to separate RF amplifiers for each frequency. This increases cost, weight and dissipated heat. This SBIR is seeking proposals and innovative techniques for constructing efficient broadband monolithic microwave integrated circuit (MMIC) power amplifiers that cover at least two of the three bands, Ku/Ka or Ka/Q bands.

PHASE I: First, the introduction of a novel technique for producing dual band (Ka/Ku or Ka/Q) MMIC power amplifiers at different output power levels and operation modes. Second, the implementation of the proposed technique in a concept design of an RF MMIC. The design should include:
1. Preliminary linear simulations.
2. Preliminary thermal analysis.
3. Estimate of MMIC area.

The preliminary MMIC power amplifier design must have the potential of satisfying the following specifications:
Input/output impedance: 50 ohm (Input Voltage Standing Wave Ratio (VSWR) 2:1, Output VSWR 3:1).
Output power (at 1 dB compression): 45 dBm.
Minimum gain across band: 30 dB.
Minimum bandwidth: 3 GHz in each frequency band.
Power Added Efficiency (PAE): 40% or more.

PHASE II: The production of a solid-state high-power power amplifier prototype that satisfies the following specifications:
Input return loss: > 15 dB.
Output return loss:> 6 dB.
Stability: amplifier stable for source and load mismatches up to 3:1 VSWR.
Output power (at 1 dB compression): 50 dBm (based on combining four 45 dBm MMICs).
Minimum gain dual-band: 50 dB.
Minimum bandwidth: 3 GHz in each frequency band.
Power Added Efficiency (PAE): 25% or more.
Size: < 15 cubic inches
Power and Protection circuitry:
A) The Solid state power amplifier (SSPA) must not be damaged by power supplies being turned on or off in an arbitrary sequence
B) Must not be damaged by power supply noise < 250 mVp-p with ~ 10 nsec-edges
C) Must not be damaged by power supply over-voltage of +15 V (above primary supply rail)

Deliverable: The prototype module (with above specifications) which should be connectorized and mounted on a heat sink.

PHASE III: There are a number of military and commercial applications that would benefit from the development of dual-band Ku/Ka MMIC power amplifiers. One of the military applications is the UAV dual-band multifunction payload system (both radar and comms) required for the Future Force. One of the commercial applications is RF links for base-station / satellite communications.

REFERENCES:
1)Mark Axtell, “Sensing the future: Technical advances expand the usefulness of UAVs,” C4ISR Journal, November 28, 2005.

2)S. I. Tsunoda, F. Pace, J. Stence, M. Woodring, “Lynx: A high-resolution synthetic aperture radar,” SPIE Aerosense 1999, Vol. 3704.

3)Schumacher, H.; Abele, P.; Soenmez, E.; Schad, K.; Teppo, T., “Low-cost Ku to Ka band MMICs using a commercially available Si/SiGe HBT process,” Microwave Conference, 2000 Asia-Pacific 3-6 Dec. 2000, pp. 776 – 779.

4)F.Coromina, F.Deborgies, F.Emma, G.Gatti, “On-board Applications of Active Microwave Technologies to GALILEO and other European Space Programs,” 12th GAAS Symposium, Amsterdam, 2004.

KEYWORDS: RF Power Amplifiers, UAV, VSAT, SATCOM, Ku-band, Ka-band

A06-197 TITLE: Lightweight, Low Cost, Seeker Gimbals

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Develop a lightweight, low cost, precision seeker gimbal assembly that can operate in environments inducing high stress levels (temperature, vibration and shock).

DESCRIPTION: The PEO- Missiles and Space has applications for precision seeker gimbal assemblies that will provide significant improvement in maintaining operation in high stress environments applicable to precision attack missiles. These high stress levels cause missile designers to add supporting structures and isolators that will minimize stress levels for the gimbal assemblies. Strengthening the gimbal supporting structures adds additional weight to the missile.

The PEO Missiles and Space is proposing an SBIR program to investigate designs for improved seeker gimbal assemblies that will allow improvements in guidance section stability in high stress environments without the need for additional mechanical structures. Present state of the art in gimbal designs rely upon considerable ancillary structural members and mechanical isolation (thereby increasing overall missile weight) to assure gimbal stability is maintained.

These innovative seeker gimbals may be used with cooled and uncooled imaging infrared sensors, millimeter wave sensors, and semi active laser sensors. The emphasis will be on alternative materials or design techniques to demonstrate innovative means to provide gimbal stability for applications in tactical missile and space applications. This effort is to focus upon, as a minimum, the innovative gimbal system itself and not the associated rate sensors which may be mounted in other locations. However, it would be desirable to consider in the innovative gimbal design, that “on-gimbal” rate sensors and electronics may be a part of potential tactical missile applications.

This program will demonstrate new and innovative concepts to existing tactical missile gimbal assembly designs within a confined missile body. The program will demonstrate a 50% improvement in sensor stabilization performance compared to existing tactical missile precision attack gimbal designs. A baseline comparison would be made using the Joint Common Missile gimbal stabilization performance. Baseline performance information can be obtained by the SBIR contractor via written request to the Technical Points of Contacts.

Proposals will not be accepted that offer improvements in sensors (such as gyros and accelerometers, etc) for increasing gimbal stability.

Future high mechanical stress environments include operating temperatures from -65F to 165F. Precision attack missile systems will operate on both fixed wing and rotary wing platforms and the innovative gimbal assembly will demonstrate stable gimbal operation in those high stress environments (defined in Appendix A using reference (b) for general test methods). It is acceptable to allow a heavier, innovative gimbal assembly that does not include the associated structural supports and isolators required by existing gimbal systems but cannot exceed 120 grams. This mass allowance includes the gimbal itself, associated gimbal packaging, any internal electrical circuitry, and connector interfaces.

A desired goal of this effort is to achieve a 25% lower cost compared to existing tactical missile gimbal designs. A realistic production unit cost would not exceed $1000-$1500 per gimbal assembly based upon expectations for 20,000 to 30,000 tactical missiles. The cost metric is expected to be achieved while maintaining sensor performance across the high stress environments.

The proposed SBIR program provides the Army with an opportunity to improve existing capabilities by use of high stress gimbals without paying penalties for additional weight from external mechanical supporting structures while maintaining gimbal assembly performance in the high stress operational environment.

Reference (1) provides the typical design parameters for tactical missile gimbal design. Reference (2) provides basic information on test methods and test procedures for high stress acceleration and vibration environments. Appendix A contains a definition of the high stress vibration environment expected to be encountered from -65degrees F to 165 degrees F.

PHASE I: Investigate alternative gimbal assembly designs that have capabilities in providing increased high stress gimbal performance within precision attack missiles bodies. Verify environmental and sensor performance through simulations.

PHASE II: Perform detailed gimbal assembly analysis, design tradeoff studies, and preliminary design of the selected innovative gimbal assembly. Build a prototype gimbal assembly and perform experiment(s) to determine levels of improvement in capabilities for operating in high vibration and mechanical stress environments from -65 degrees F to 165 degrees F. The deliverables will be submission of two prototype gimbal assemblies and a detailed gimbal design analysis technical report.

PHASE III: The military application for this technology is in the guidance/ seeker assemblies for Tactical Missile Systems for rotary and fixed wing platforms. There are numerous commercial applications for precision gimbals. Some commercial applications that may benefit from this SBIR include the commercial space satellite industry and the commercial aircraft cockpit avionics industries.

REFERENCES:
1) For information only. www2.southernresearch.org/pdf/gimbals.pdf
2) www.dtc.army.mil/pdf/810.pdf. For general test methods and procedures, MIL STD 810F temperature range from -65F to 165F, Method 513.5 (Acceleration), Structural Test for aircraft/helicopters/Aircraft stores and Method 514.5 Categories 12-19.

KEYWORDS: seeker gimbals, high stress gimbals

A06-198 TITLE: Far Target Locator

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Investigate, design, and build a lighter, affordable Far Target Locator for use on man-portable target acquisition, fire control and missile launchers.

DESCRIPTION: The Program Executive Office, Missiles and Space (PEO MS) has a requirement to add a networkable Far Target Locator capability to their man-portable fire control and missile launchers. These man-portable fire control systems employ imaging long wavelength infrared (LWIR) technology for man in the loop target detection, recognition, and identification. These widely deployed fire control systems and launchers are often utilized for battlefield surveillance. The current fire control systems do not have the ability to determine and report their own position nor compute the grid coordinates of a potential target or item of interest. A Far Target Locator would integrate with the fire control system to provide critical target information (range, azimuth and grid coordinates) and CLU imagery of the target that could then be networked via radio to other elements of the squad and to higher echelons of command. This topic proposes to investigate, design, and build a lightweight, affordable Far Target Locator. Weight and affordability are important considerations for all components of man-portable weaponry and will be a primary focus during the development. The program will focus on development of a self-contained device that can be mounted to the Javelin Command Launch Unit (CLU) in place of the missile. Powered by a disposable battery, the CLU provides the capability for battlefield surveillance, target acquisition, missile launch, and damage assessment. The Far Target Locator shall draw power from the CLU which is powered by a BA 5590 battery. The Far Target Locator should minimize power consumption to minimize impact on the CLU's operating requirement of four hours. The program will demonstrate the Far Target Locator's ability to provide self-position and range, azimuth, and grid coordinates of a target at 3 – 4 kilometers range. The desired accuracy goal for a 3-kilometer target is a Circular Error of Probability (CEP) of 23 meters, Vertical Error of Probability (VEP) of

15 meters, and Spherical Error Probability (SEP)of 30 meters. The Far Target Locator should communicate the target information via a Single Channel Ground and Airborne Radio System (SINCGARS) and/or Enhanced Position Location Reporting System (EPLRS) radio. The Far Target Locator will interact with the CLU to allow the operator to identify the target of interest via the CLU operator display. The Far Target Locator should also transmit this information to the CLU so the CLU could display the information on the internal user display. The Far Target Locator should capture a single video frame from the CLU and send a digital still image via SINCGARS or EPLRS. The weight goal for the Far Target Locator is 8 pounds with a maximum weight of 12 pounds. The proposed effort will provide the Army with an opportunity to improve existing surveillance sensors.

PHASE I: Design a Far Target Locator that calculates self-position as well as range, azimuth, and grid coordinates of a target at a distance of 3 – 4 kilometers. Trade studies will be conducted to assess and mitigate the technical risks associated with the integration of key technologies such as commercial off the shelf and custom Global Positioning System engines, electronic compass and flux gate technologies and both passive and active range finding devices. Appropriate components from these technologies will be evaluated, analyzed and selected in this phase. An assortment of data compression and error correction techniques should be examined to mitigate the technical challenge of minimizing bandwidth requirements for data transmission and to maximize the successful transmission of data. The Far Target Locator shall be designed to transmit the target information listed above and the digital image to a secondary computer using an industry standard digital protocol. The digital target information and still image data shall be ported from the Far Target Locator for transmission via SINCGARS or EPLRS radios. The physical encasement of the Far Target Locator shall be capable of being mounted to the Javelin CLU in the location that the missile is usually attached. The Far Target Locator shall maintain proper calibration with the CLU optics to ensure that the target selected on the operator display is in fact the target ranged by the Locator. The accuracy of self-position and target information shall be tested through field tests of defined targets and locations. The cost for the initial Far Target Locator units should not exceed $20,000.

PHASE II: Package, demonstrate and refine the design developed in Phase I. Miniaturization shall be investigated and implemented. Investigations into electronic components and modules that could be combined shall be performed from information/understanding of functionality and interface requirements gained during Phase I with the goal of reducing system weight and cost and improving performance and reliability. This phase will have a cost goal of $12,000 for quantities of 2000 and an improved accuracy of 40% over that demonstrated in Phase I.

PHASE III: In Phase III, the Far Target Locator will be further miniaturized and mounted on the CLU in a manner which also allows the missile to be mounted simultaneously. This will give the Javelin system the flexibility to act as a surveillance asset while simultaneously performing attack missions. The Far Target Locator technology can be repackaged with digital optics (camcorder or still camera) and digital data display for stand alone use for Homeland Security and Public Safety applications such as border surveillance, forest fire mapping and law enforcement tracking of drug transactions. Such a stand alone system could easily interface to a personal computer for capture and transmission of sensor data over conventional computer networks.

REFERENCES:

1) Federation of American Scientists, public domain overview and synopsis of the Javelin weapon system, available at: http://www.fas.org/man/dod-101/sys/land/javelin.htm
2) Defense Magazine public domain overview of the BA 5590 Lithium battery, available at: http://www.defense-update.com/products/b/ba5590.htm
3) Field Manual, FM 3-22.37. Javelin Medium Anti-armor Weapon System, Jan 2003.
4) MIS-45944, Prime Item Development Specification, Javelin Command Launch Unit (CLU). Jan 2005.
5) 13303329, Javelin Round/Command Launch Unit Mechanical Interface Control Drawing. Apr 2004.
6) 13497853B, Javelin Command Launch Unit (CLU) Test connector Interface Control Drawing. Nov 2004.

KEYWORDS: Target Location, Far Target Locator, manportable sensors, man-portable sensors, lightweight

A06-199 TITLE: Focusing a Thermobaric/High Explosive Blast Wave

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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: Design and build a medium caliber projectile that can be safely fired out of a weapon, provides a safe stand-off distance and directs/concentrates the energy of the blast in a 2-3 ft diameter area towards the front of the projectile. The blast must minimize collateral damage to the operator of the system from back blast or fragmentation.

DESCRIPTION: In order to defeat certain material targets (doors, windows etc.), medium caliber munitions require the energy of a blast wave concentrated over a 2-3 foot diameter area. The M100 Grenade Rifle Entry Munition (GREM) system is a muzzle launched munition fired from a rifle that delivers a wide diameter explosive charge to within a preset distance from the surface of the door to be breached and initiates a high explosive blast that defeats the door. The system can be safely fired from 15-40mm without collateral damage due to the fact that upon initiation minimal fragmentation occurs based on material choice of a nonmetal backing. The wide nature of the explosive charge optimizes the blast wave and a standoff rod sets off the explosive charge a foot away from the target. The system is bulky and expensive, and a non-muzzle launched ordnance is desirable, preferably in a 40mm configuration (M203/XM320) or 25mm (Objective Individual Combat Weapon/Advanced Crew Served Weapon) configuration. Use of thermobarics has been explored in a 40mm configuration with limited success, and there is a current program to provide the one foot standoff distance though there is no current method available to spread the blast over a desired area with enough knockdown power. High Explosive or Thermobarics in that small diameter configuration requires innovation/research in shaping the blast towards the desired area. This effort requires: analysis of the interactions of the explosive charge, charge dispersion, and direction, velocity, etc.; determination of optimum standoff, charge focus and type; and development of an innovative approach to shaping the blast wave to accomplish the optimal solution. A benefit currently in examining a medium caliber configuration is that in the case of say 40mm, the prospect of a longer cartridge is now a possibility (the XM320 grenade weapon system), whereas in the past the length of round was confined, i.e. the M203 system. The increased length allows for more explosive within that boundary constraint for the 40mm diameter.

PHASE I: Provide an overall system approach that includes calculations, material assessments, simulation and modeling, etc. that leads to proposed candidate designs for subsequent testing. Conduct preliminary laboratory testing if possible.

PHASE II: Develop and demonstrate a prototype system, measure the overpressure of the blast at predetermined locations and test against various material targets.

PHASE III: The completion of this phase would result in a mature technology, which could be successfully applied to military, law enforcement and homeland defense applications and in forming metal parts explosively in commercial metal forming industries.

REFERENCES:
1) “Thermobarics: Promises, Challenges and Recommendations (Unclassified),” Kibong Kim, 7th Joint Bombs/Warheads & Ballistics Symposium, Monterey, California, 9-12 August 2004
2) "Advanced Energetics Materials", ISBN 0-309-09160-8; report by Committee on Advanced Energetic Materials and Manufacturing Technologies, Board on Manufacturing and Engineering Design, Division on Engineering and Physical Sciences; National Research Council of the National Academies, The National Academies Press, Washington, D.C.; 2004; http://www.national-academies.org/bmed
3) "Energetics of Aluminum Combustion"; Peter Politzer, Pat Lane, and M. Edward Grice; J. Phys. Chem A 2001, 105, 7473-7480.

KEYWORDS: Directed Blast, High Explosive, Thermobarics

A06-200 TITLE: Articulated Soldier Knee and Elbow Protection System

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design and build an articulated armored knee and elbow protective system that will prevent damage to the Soldier's knees and elbows from ballistic threats (blunt impact, high velocity small arms, and fragmentation impacts). The baseline ballistic protection will be equal to or better than what is currently provided by the Army Combat Helmet. System must interface with Army Combat Uniform (ACU) and cannot degrade a Soldier's maneuverability during combat operations.

DESCRIPTION: High intensity ballistic impacts to arm and leg joints cause immediate and severe debilitation during combat. Subsequent degradation of combat power and increased vulnerability to both the victim and responding medical personnel is inevitable. These injuries are largely responsible for costly and often lifelong disabilities. This system focuses comprehensive protection capabilities on vulnerable body locations that need additional protection. Current knee and elbow pad systems are stand-alone components that do not adequately interface with the combat clothing platform (Soldier and ACU) and provide only limited impact protection. There are a number of DoD efforts to improve ballistic protection. However, current efforts focus on enhanced protection for the head, torso and extremities (feet). There are currently no specific efforts to provide protection upgrades to the knee and elbow joints. This unique integration of ballistic and blunt impact protection to knee and elbow joints will require innovative application of rigid ballistic armor (e.g., composite aramid, carbon fiber, Ultra High Molecular Weight Polyethylene), flexible articulating joints, effective retention systems, and anthropomorphic shaping. Potential application of "liquid armor" (Shear Thickening Fluids) is possible.

PHASE I: Provide an overall system approach that includes calculations, material assessments, simulation and modeling, etc. that leads to proposed candidate designs for subsequent testing. Conduct preliminary laboratory testing if possible.

PHASE II: Develop and demonstrate a prototype system, providing an assessment of ballistic protection values, impact on range of motion, and efficiency of interface with protective clothing systems.

PHASE III DUAL USE APPLICATIONS: Successful technologies developed under this effort will be transitioned for military application by Project Manager Soldier Equipment as a part of a pre-planned product improvement to the Soldier knee and elbow protection system. Further application extends to Explosive Ordnance Disposal and Countermine Engineer protective ensemble items. Potential commercial applications include recreational and occupational safety, as well as law enforcement and first responders.

REFERENCES: NIJ Standard 0101.04 Type III-A (9mm FMJ 8.0g 1400 + fps);
http://peosoldier.army.mil/.

KEYWORDS: Knee Pads, Elbow Pads, Articulated Joints, Protective Equipment, Survivability

A06-201 TITLE: Robust Single Frequency GPS Receiver Carrier Phase Measurements in a Mobile Ad Hoc Wireless Network

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Achieve sub meter position accuracy for dismounted soldier simulated tactical engagement training.

DESCRIPTION: Location and navigation are important functions of dismounted soldier training and operational testing. Continuous availability, high accuracy and high reliability are required in order to maximize training effectiveness (realism) during simulated tactical engagements and to achieve high fidelity operational testing capability during real-time casualty assessments (RTCA).

Sensor-based simulated tactical engagements require a minimum position/location accuracy of 1 meter (1 s) horizontal and 1.5 meter (1 s) vertical, however, better accuracy results in improved tactical engagement fidelity which yields realistic training; the horizontal accuracy goal is 20 cm (1 s) and the vertical accuracy goal is 30 cm (1 s). This positioning accuracy must be achieved autonomously, meaning that the GPS receiver must achieve these accuracies without the use of infrastructure such as the Federal Aviation Administration's (FAA) Wide Area Augmentation System (WAAS) differential correction service. Additionally, these accuracies must be achieved with a single frequency (L1, C/A code) type of GPS receiver.

Conventional carrier phase measurement techniques use two or more dual frequency (typically L1 and L2) receivers that are connected to each other through some wireless communications means - one of the receivers remains fixed and serves as a reference station throughout the measurement period. Though these receivers are networked together, they are in a centralized, server/client, type architecture in which the communications links are stable and the quality of service (e.g.; latency, packet delivery ratio) excellent.

Solutions are sought that involve the use of up to 60 single frequency mobile GPS receivers, all wirelessly linked using a Mobile Ad Hoc Network (MANET) protocol in which links between receivers are constantly being formed and broken without the need for a fixed reference receiver (all receivers can be dynamic). MANET is a decentralized, peer-to-peer, architecture in which carrier phase measurement data would be relayed (shared) to one or more receivers in the network. The following are threshold (T) and objective (O) metrics for this topic:

- Dynamic position/location accuracy:
- 1 m (1 s) horizontal and 1.5 m (1 s) vertical (T)
- 20 cm (1 s) horizontal and 30 cm (1 s) vertical (O)
- Number of MANET-linked receivers: 10 (T); 60 (O)
- Time required to resolve carrier phase ambiguities: < 500 msec (T); 200 msec (O)

PHASE I: A computer model of 2 mobile GPS receivers and their wireless links will be created that will be used to characterize and evaluate how the quality and instability of the communications links affect carrier phase ambiguity resolution measurements. Once error mechanisms are understood, new solution concepts will be modeled and simulated to establish feasibility of conducting measurements that can maintain accuracies of 1 meter or better in highly unstable communications links involving a MANET of 5 mobile GPS receivers.

PHASE II: New solution concepts will be modeled and simulated to establish feasibility of conducting measurements that can maintain accuracies of 1 meter or better in highly unstable communications links involving a network of 60 mobile GPS receivers. Laboratory experiments will be conducted using these new algorithms in a mobile GPS receiver network consisting initially of 5 GPS receivers. Follow on experiments will consist of networks formed by 10 mobile receivers and at the completion of Phase II, 20 receivers will be used to finalize the validity of performance robustness in a user relevant environment.

PHASE III: This technology would have application for the U.S. Army's simulated tactical engagement training program (the One Tactical Engagement Simulation System (ONETESS)) to fulfill their need for training realism at training centers, home station and during deployments. It also has DOD application in developmental testing where precise location data is required to conduct real time casualty assessment. Commercially, the resulting technology could be used for land surveying, intelligent transportation systems involving automatic guidance, mobile Geographic Information System (GIS) mapping, and for regional-scale seismic surveys to monitor deformation of the earth's crust.

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1) Omar, S. and Rizos, C (2003), "Incorporating GPS into Wireless Networks: Issues and Challenges", presented at the 6th International Symposium on Satellite Navigation Technology Including Mobile Positioning & Location Services.
2) Y. Bock, P. de Jonge, D. Honcik and J. Fayman, Geodetics, Inc., La Jolla, CA, "Wireless Instantaneous Network RTK: Positioning and Navigation"

3) Luo, N., and G. Lachapelle (2003), "Relative Positioning of Multiple Moving Platforms using GPS", IEEE Transactions on Aerospace and Electronic Systems, 39, 3, 936-948.

KEYWORDS: Global Positioning System (GPS), GPS receiver, real time kinematic (RTK), carrier phase ambiguity resolution, wireless networks, mobile ad hoc network (MANET)

A06-202 TITLE: ICAS: Intelligent Control of Autonomous Systems

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a framework that allows a single user to control multiple unmanned assets with adjustable levels of autonomy.

DESCRIPTION: There is a growing need in the military, commercial, and scientific sectors for real-time autonomous reasoning systems that can maintain internal representations and reason about their environment. Current systems tend to be real-time control systems that address low level autonomic issues associated with robotic mobility, or deep reasoning planners that do not operate in real-time. The Army wishes to investigate technologies that allow the warfighter to utilize both types of systems without high cognitive load or high training requirements. Systems built to employ the resulting technologies should exhibit intelligent and autonomous behavior in challenging real-world environments. Increased autonomy will directly reduce the number of humans required for system control, thereby decreasing operational and training costs. It also has the potential to improve overall system safety and performance.

While significant advances have been made in implementing low-level autonomic decisions, such as those concerning basic robotic mobility, robotic systems are still weak in the higher-level cognitive areas of planning, learning, and interacting with human controllers. The main difficulty lies in the kinds of reasoning that autonomous systems need to perform successfully at these different levels. At the lowest level, autonomous systems must be able to process sensor data, including geometric knowledge and metrical maps, and react to their current environment. This reactive reasoning has traditionally been the province of robotic control research. This research has provided the basis for systems that use rapid feedback loops to map sensory inputs to actuator outputs. The amount of information that these feedback loops can process is constrained by the speed requirements of these real-time systems, making inclusion of higher-level goal information difficult. Although low-level action autonomy is helpful to a warfighter, the full promise of the FCS requires that agents operate and propose actions based on higher-level cognition, such as making plans and communicating with the warfighter.

Cognitive architectures (Newell 1990), which come from the AI research tradition, have approached the problem of an agent's decision-level autonomy by developing a deliberative, symbol-processing, problem-space based reasoning system. Many of these cognitive approaches have a research tradition that models human decision-making and have a strong capability for real-time reactive processing. This topic area is interested in approaches that use cognitive architectures for autonomous command and control of unmanned assets.

Research challenges:
• Develop knowledge representation requirements and structures to communicate agent intention and execution to the warfighter.
• Develop techniques for situation understanding, particularly managing pertinent historical information, grouping objects into situations, update the representation as external world-state changes, and respond to situation change.
• Explore the implications of adjustable autonomy, particularly upon system communications with warfighter, execution inside an agent system, and visual representation of adjustable autonomy and its implications to the warfighter.
• Determine the implications of real-time constraints on a cognitive architecture, particularly investigation into implementing both hard and soft real-time constraints in an architecture and how that will affect the process of encoding knowledge in cognitive architectural agent systems.

Relevant technologies:
Potentially relevant technologies include geometric and geographical representation, modeling the user, situation modeling, learning, situation uncertainty, Bayesian networks, data fusion, task models, BDI models, mixed-initiative-interaction, and threat assessment.

PHASE I: Design an adjustable autonomy system for expanded warfighter control with user interaction. The system will allow the user to control multiple unmanned assets of varying levels of autonomy.

PHASE II: Develop and test a prototype of the adjustable autonomy system designed in Phase I. For example the system may allow the user to tele-op an EOD UGV while monitoring multiple surveillance UAVs that are patrolling their perimeter.

PHASE III: Phase III three will focus on integrating the prototype with an existing system such as the TARDEC Crew-integration and Automation Testbed (CAT) as well as identifying and developing models for specific vehicle types for both military (manned, tele-operated, FCS, small UGV) and civilian applications. Specific civilian applications could include expanding the intelligent capabilities of web search engines to include intent analysis. Another possible use could be used to enhance the control and user interface of search and rescue robots.

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2) Brooks, R., A robust layered control system for a mobile robot. IEEE Journal of Robotics and Automation, RA-2:14-23, 1986.
3) Firby, R. James: An Investigation into Reactive Planning in Complex Domains. AAAI 1987: 202-206.
4) Jones, R. M., Laird, J. E., Nielsen, P. E., Coulter, K. J., Kenny, P., and Koss, F. V. (1999). Automated intelligent pilots for combat flight simulation. AI Magazine,V20n(1), p.27-41.
5) Laird, J. E.; Coulter, K. J.; Jones, R. M.; Kenny, P. G.; Koss, F. V.; and Nielsen, P. E. Integrating Intelligent Computer Generated Forces in Distributed Simulation: TacAir-Soar in STOW-97. In Proceedings of the 1998 Simulation Interoperability Workshop. Orlando, FL.1998.
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8) Wray, R. E., Laird, J. E., Nuxoll, A., and Jones, R. M. (2002). Intelligent Opponents for Virtual Reality Training. Proceedings of 2002 Inter-service/Industry Training, Simulation, and Education Conference (I/ITSEC). Orlando, FL.

KEYWORDS: real-time autonomous reasoning systems, robotic mobility, deep reasoning planners, higher-level cognition

A06-203 TITLE: <u>UGV Dynamic Mobility Updates Using Real Time Prognostic and Diagnostic Information</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: To use real time prognostic and diagnostic information to update the mobility characteristics of an Unmanned Ground Vehicle (UGV).

DESCRIPTION: The state of the art with regards to autonomy for robotic vehicles has been increasing exponentially in recent years. Autonomous vehicles are doing an increasingly better job of modeling the terrain they traverse, understanding their inherent capabilities, and lessening the mean time between unintended human interventions because of failure modes. However, these vehicles are still surprisingly naïve to changes in their own condition or state. This is in a direct conflict to the advancements being made in vehicle prognostics and diagnostics. Autonomous navigation is primarily accomplished by core enabling technologies dependent on the complexity of the system. Lower level systems generally relay on GPS for navigation with one or two primary sensors to do obstacle detection and avoidance. More advanced systems like the FCS Mule or ARV have a full array of sensors for obstacle detection, avoidance and terrain modeling. They have a navigation system with a tightly coupled GPS/INS, as well as, a priori data about the terrain to be traversed and the vehicles mobility characteristics (mass of vehicle, acceleration profile, turning radius, top speed, center of gravity, fuel consumption, etc…). All of these highly complex systems are working with a static definition about their mobility characteristics (e.g. NATO Reference Mobility Model (NRMM)). This static model impedes these systems from making the next step towards true autonomy. Because the mobility characteristics of the vehicle will change dependent on the vehicles state, a dynamic reference model is needed. Some examples are shown below:

- If a wheel or track on a UGV is damaged the intrinsic mobility is degraded.
- If a vehicle has a engine problem the power output is reduced.
- If the weight or center of mass of the vehicle has changed due to additional or new payloads the vehicle no longer performs as the model predicts.

A human operator can adapt to any of the above situations and continue their mission. Current UGVs do not have this capability. A lot of work has been done of late in the fields of vehicle prognostics and diagnostics. It is the intent of this SBIR to take these tools designed to assist the operator of manned systems and apply them to assist the control systems for unmanned vehicles.

PHASE I: This phase will determine what are the fundamental and essential parameters required to successfully model and control unmanned ground vehicles? How dynamic are they? How often do they need to be monitored? What is the cost to monitor verses the value added? For example, a NRRM model may have a thousand parameters. Not all of them change with time. Nor do those that change, change at the same rate. This study would determine which (and how many) of those one thousand parameters have the most impact on the vehicle. It would determine how the accuracy and timeliness of these dynamic parameters can best assist the UGV controller. It will probably be best to look at an individual UGV or class of UGVs.

PHASE II: A Phase II award would develop a prototype system based on the Phase I research and implement it on an unmanned ground vehicle. This implantation will be tested showing vehicle performance with and without the dynamic mobility model under multiple operational conditions. An analysis of this comparison, as well as the hardware involved, will be the deliverables of Phase II.

PHASE III: Phase III will focus on identifying and developing models for specific vehicle types for both military (manned, tele-operated, FCS, small UGV) and civilian applications. Specific civilian applications include state awareness for vehicle stabilization and path-planning in EMS vehicles and advanced tele-operated control of disaster relief robots given detailed vehicle health feedback to the operator.

REFERENCES:
1) Dr. Frank L. Greitzer, DETERMINING HOW TO DO PROGNOSTICS, AND THEN DETERMINING WHAT TO DO WITH IT. http://www.pnl.gov/redipro/Papers/Autotestconpaper076.pdf
2) M. Likhachev, Spatio-Temporal Case-Based Reasoning for Efficient Reactive Robot Navigation. http://www.cc.gatech.edu/ai/robot-lab/online-publications/LikhachevEtAl2005.pdf.
3) Thomas J. Walter , Diagnostics and Data Fusion of Robotic Sensors. http://www.netl.doe.gov/publications/proceedings/97/97em/em_pdf/EMPII-4.PDF.
4) A. Barrett, Model Compilation for Real-Time Planning and Diagnosis with Feedback. International Joint Conference on Artificial Intelligence (IJCAI 2005). Edinburgh, Scotland. July 2005.

KEYWORDS: Robotics, Mobility, Prognostics, Diagnostics, Autonomy, Route Planning, Mobility Model, NATO Reference Mobility Model (NRMM), proprioceptor

A06-204 TITLE: Miniature Explosive Pulsed Power for Missiles and Munitions

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 objective of this effort is to develop miniature explosive driven pulsed power technologies to power a variety of missile and gun launched payloads.

DESCRIPTION: Explosive pulsed power systems consist of those devices that convert the chemical energy of high explosives or propellants into electrical power and condition this power to drive a variety of loads. The objective of this effort is to develop very compact explosive pulsed power devices capable of generating sufficient power to drive multiple types of payloads. Based on decades of R&D, the best candidate for this power supply is the Helical Magnetocumulative Generator (HMCG), which is also called a Helical Flux Compression Generator (HFCG). However, recent research has established that when the diameter of these generators decreases below 50.8 mm (2 inches), they produce no current or energy gain. Therefore, the focus of this effort is to develop alternative MCG designs and their associated power conditioning technologies that will produce current and energy gains when their diameters are as small as 25.4 mm (1 inch). The selected vendors will have the flexibility to look at alternative geometrical designs (loop, plate, strip, bellows, etc.), selections of energetic materials (explosives vs. propellants), power conditioning technologies, and construction materials (e.g., nanomaterials, ferroelectrics, ferromagnetics, and alloys) in developing high current generators. References 1 and 5 give a summary of work done to develop explosive pulsed power systems of various geometries and References 4 and 5 can be made available upon request. These generators have a number of military applications including driving high power lasers, high power microwave and ultra wideband sources, detonator arrays, railguns, burst communications, and expendable sensors. Commercial applications include driving fusion reactors (Department of Energy); microfusion propulsion (NASA); expendable x-ray sources and neutron generators for nondestructive testing, destruction of biological waste, and diagnosing energetic events; powering detonator arrays in mining, oil and mineral exploration, starting vehicles in extreme cold environments, emergency burst communications, and manufacturing processes requiring large amounts of electrical current over a short period of time (e.g., metal forming).

PHASE I: Identify potential technologies and analyze, design, and conduct proof-of-principle demonstrations: 1) to verify that the proposed explosive pulse power device design output is predictable and is consistent with predictions and 2) to assess their ability to drive various loads and meet the form factor size requirements.

PHASE II: Design, build, and test enhanced prototype explosive pulsed power devices and their associated power conditioning equipment, 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 25.4 mm. Other issues that should be addressed in Phase II are hardening the technology to survive high g-force launches and designing manufacturing processes for mass production. The selected Firm will be encouraged to work with various vendors to develop a commercial product.

PHASE III: The explosive pulsed technologies developed under this effort could be applicable to multiple military and commercial applications requiring pulsed power. Commercial applications include their use in water purification units, nondestructive testing systems, portable lightning simulators, portable expendable X-ray sources, and oil and mineral exploration. Military applications include their use as power supplies for driving microwave and laser payloads, detonator arrays, and fuzes such as exploding foil initiators. The responsible government agency will work with the selected Firm to identify potential commercial partners.

REFERENCES:

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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: Explosive pulsed power, power conditioning, magnetocumulative generator, sensors, propulsion, nondestructive testing, minearl explroration.

A06-205 TITLE: Solid State High Energy Laser Component Technology

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To research and develop innovative Solid State High Energy Laser (HEL) component technologies that will continue to advance the state-of-the-art in 10+kW class Solid State Laser (SSL) systems. Component technologies of interest include high efficiency pump diodes, high temperature dump diodes, adaptive optics for laser beam correction, fast steering mirrors for jitter control, innovative thermal management for diode and lasing medium cooling, ceramic lasing mediums, etc.

DESCRIPTION: As HEL 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 includes both system level and component technology. 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 concepts which would enable and increase performance of high-brightness, high-power operation of solid state lasers. It is envisioned that technologies investigated and developed under this SBIR topic could be inserted the Joint High Power Solid State Laser (J-HPSSL) program or follow-on efforts to develop a high power, high efficient solid state laser tactical demonstrator. Potential areas include: beam shaping and clean-up techniques, beam control components and algorithms, beam combining, heat removal, high efficient diodes, optical coatings, beam directors, ceramic slabs, etc.

PHASE I: Conduct research, analysis, and studies on the selected area and develop measures of performance enhancement and document results in a final report. The phase I effort should include modeling and simulation results supporting performance claims. The effort may also produce a preliminary design and a draft testing methodology to demonstrate the enhancement during the phase II effort.

PHASE II: During Phase II, a testable breadboard will be designed and build based on the phase I preliminary design to conduce 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: A high-power, high-efficiency solid state lasers have the capability of adding tremendous value to land and air directed energy platforms for both attack and protection. High energy solid state lasers are also sources of material processing in the automotive, aircraft, and other large manufacturing industries. A 10+kW solid state laser device with a near diffraction limited beam quality and >15% wall plug efficiency will be the goal in a phase III effort.

REFERENCES:
1) W. Koechner, "Solid-State Laser Engineering fifth revised and updated edition" Springer-Verlag, 1999.
2) Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974.
3) Annual Directed Energy Symposium Proceedings available at:
http://www.deps.org/DEPSpages/forms/merchandise.html.

KEYWORDS: Solid State Laser (SSL), High efficient laser diodes, Durable optical coatings, Beam Control, Beam Quality, Ceramic Lasing Medium, Fast Steering Mirrors, Adoptive Optics, Thermal Management

A06-206 TITLE: Automated Real Time Pose Determination

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: Demonstrate the ability to match a 3-D model to a 2-D Synthetic Aperture Radar (SAR) image in near real-time.

DESCRIPTION: The Department of Defense has conducted numerous research efforts in the area of Automatic Target Recognition (ATR). There is clear military utility in the ability to automatically scan sensor data to determine the presence of military targets, most often military vehicles. There have been numerous successes and setbacks in this area. Some of the more challenging aspects of ATR efforts are targets that are often partially occluded, camouflaged or in a non-standard configuration. These situations create uncertainty in automatically determining both the existence and subsequent type of target. In some situations where the target is not occluded and the target shape and configuration is well known, there is military utility in determining the orientation or pose of the target provided the information can be obtained in near-real-time. This SBIR topic is seeking a near-real time capability to automatically determine the orientation of known targets, i.e., we know it is a particular type of vehicle and we desire to know which way it is pointing. Target models (3-D CAD) are available that can be ‘matched’ to the sensory data in making this determination. The challenging aspect of this problem is that the sensory data consist of 2-D Synthetic Aperture Radar (SAR) data of coarse resolution. For this application, some of the processes and procedures used in manufacturing for determining the orientation of parts within a bin may be applicable. The system must automatically scale and translate the data, ‘match’ the model and determine the orientation of the object to within 5 degrees. A set of sample data and models will be provided to support development.

PHASE I: The objective of Phase I is to develop and demonstrate an algorithmic approach to enable the near-real time determination of an object’s pose. The contractor will be given representative samples of 2-D SAR images and a generic model of the object. The Phase I objective is to develop and demonstrate the near real-time performance of algorithms that will enable the model matching. It is expected that the Phase I effort will be conducted in some developmental environment such as MATLAB. The Phase I effort will quantify algorithm performance and identify strengths and weaknesses of the approach. It is understood that there may be ambiguous conditions in which a singular 3-D solution can not be discerned from 2-D images. The system must identify these cases where multiple solutions may exist. It is preferred that the solution developed should not be model dependent or based on specific features of the objects. A generalized approach, applicable to a wide variety of objects is preferable. The system must process imager data, scale and translate images automatically.

PHASE II: The objective of Phase II is to refine the approaches developed during Phase I to incorporate multiple targets and multiple objects. The system must be able to readily accept new models and automatically correlate images to the new model. Phase II will require the porting of algorithms to a government designated computer system for field demonstration with an operational Army sensor system. Phase II culminates in field tests with actual Army hardware.

PHASE III: The objective of Phase III is to transition capability to a Army program of record for operational use. Commercial applications include image reconstruction software applicable to medical imaging systems.

REFERENCES:

1) Three- Dimensional Target Visualization from Wide-angle IFSAR Data, Moses, Randolph L., Paul Adams, and Tom Biddlecome, 2005, The Ohio State University, Department of Electrical and Computer Engineering, 2015 Neil Ave, Columbus, OH 43210 (moses.2@osu.edu).
2) IFSAR Processing for 3D Target Reconstruction, Austin, Christian D., and Randolph L. Moses, 2005, The Ohio State University, Department of Electrical and Computer Engineering, 2015 Neil Ave, Columbus, OH 43210 (moses.2@osu.edu).
3) Pose Estimation in Automatic Object Recognition, Chang, C. Y., and Richard Hoepner, Texas Instruments Defense Systems and Electronics, SPIE Vol 2752, page 233, 1996.
4) 3D LADAR ATR Based in Recognition by Parts, Sobel, Erik, Joel Douglas and Gil Tettinger, ALPHATECH Inc, Automatice Target Recognition XIII, Firooz A. Sadjadi, Editor, Proceedings of SPIE Vol. 5094 (2003) SPIE 0277-786X.

KEYWORDS: Automatic Target Recognition (ATR), Near Real-time, Pose Determination, Automated orientation determination

A06-207 TITLE: Counter Mortar Technologies

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop innovative technologies to counter the effectiveness of mortar and rocket harassing attacks against the United States Forces that are operating either at fixed locations or as members of moving convoys.

DESCRIPTION: Mortar and rocket attacks against U.S. Forces located at fixed locations or moving with convoys constitute an ever increasing threat with little or no defense against them. Due to the mobility and speed of execution of these types of threat, they are very attractive options for the enemy to use. Due to the lack of fixed battle lines and distribution of traditional counter-battery fire capability, location of the launch point for these threats is difficult to determine and, due to the fact that the launch positions are usually within mixed hostile and friendly populations, the enemy finds it easy to collect targeting information in order to conduct a precision mortar or rocket strike. The near term Army, Counter Rocket, Artillery, and Mortar,(C-RAM), capability depends primarily on the 20mm Phalanx Close in Weapon system as one of the systems utilized. Tests have shown only around 60% shoot-down capability but with potential of collateral damage. Therefore, there is an extreme need to develop technologies that would provide U.S. Forces with accurate detection and tracking of mortars and rockets when still in ballistic trajectory and that would provide the capability to counter and disable them, while doing so in a easily distributed system with minimal impact on existing convoy tactics, techniques, and procedures. The major objective of this effort is to develop lethal methods, including advanced guidance and control techniques for defeating mortar and artillery rounds and ensuring their destruction in flight. The technologies identified to defeat mortar rounds must be designed to eliminate or reduce to the minimum collateral damage by the intercepted mortar round or by the device used to engage it. Technologies of interest include smart, low cost projectiles with penetrating capability but with sufficient lethality to defeat armored RAM threats and capability to reduce colateral damage. Incorporation of energetic materials into the projectile structure in order to increase their lethality capability and reduce colateral damage could be included. Development of advanced guidance techniques to be incorporated into the projectile, that should reduce the cost per kill while perform with high confidence in a low emissivity saturated target environment is also of interest.

PHASE I: The objective of the Phase I is to analyze, and develop the design of the projectile including advanced guidance and control techniques to be incorporated into the projectile design. Verification of lethality against targets of interest through first order analysis should be part of the Phase I efort.

PHASE II: The objective of the Phase II is to develop and demonstrate a prototype of the proposed smart projectile, conduct tests against targets of interest and assess cost per kill.

PHASE III: The objective of the Phase III is to refine the engineering prototype and transition the system to U.S. Forces. Commercial applications include collision avoidance, mine clearance, UAV guidance, law enforcement applications, accurate sensors for remote sensing applications.

REFERENCES:

1) R. M. Lloyd, Conventional Warhead Systems Physics and Engineering, Progress in Astronautics and Aeronautic Series, V-179, AIAA, ISBN: 1-56347-255-4.
2) J. Carleone, Tactical Missile Warheads, Progress in Astronautics and Aeronautic Series, V-155, AIAA, ISBN: 1-56347-067-5.
3) MORTAR, 60MM, LIGHTWEIGHT COMPANY M224, Army Technical Manual TM 9-1010-223-34&P.

KEYWORDS: lethality, mortars, rockets, sensors, radars,projectiles, energetics, guidance and control

A06-208 TITLE: Innovative High Energy Laser Technology

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To research and develop innovative High Energy Laser (HEL) architectures and technologies to advance the state of newly developing laser technologies that will potentially support power levels greater than 10 kW. Architectures and technologies could include fiber lasers, thin disk lasers, spinning thin disk lasers, etc.

DESCRIPTION: It has been determined that high energy lasers can potentially provide a tremendous benefit for area protection against rockets, artillery, and mortars (RAM). For a HEL system to be of benefit on the modern battlefield it must be reliable, maintainable, portable, and cost effective. Currently, slab based solid state lasers are leading the way. The focus of this SBIR is to invest in innovative technology that is not slab based that can potentially use to spirally improve upon slab solid state laser devices and has to potential to produce power levels exceeding 10 kW. These newer cutting edge laser concepts are envisioned to be smaller, more compact, more flexible, higher power to mass ratio, less thermal management issues, and potentially cheaper. The current state of the potential technologies and architectures covered under this topic may be considerably less then a kW. The purpose of this effort is to show through modeling and simulation, component testing and ultimately building a breadboard in phase III how the power scaling may go to achieve the desired greater than 10kw power level.

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. 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 design will be completed and selected components will be tested to help verify the design concept. The data, reports, and prototype hardware will be delivered to the government upon the completion of the phase II effort.

PHASE III: During Phase III a breadboard will be build based on the phase II concept. Building and testing 10+kW laser breadboard device with a near diffraction limited beam quality and >15% wall plug efficiency will be the goal in a phase III effort.

REFERENCES:
1) W. Koechner, "Solid-State Laser Engineering", Springer-Verlag.
2) Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974.
3) Annual Directed Energy Symposium Proceedings available at:
http://www.deps.org/DEPSpages/forms/merchandise.html.

KEYWORDS: Thin Disk Lasers, Fiber Lasers, Spinning Thin Disk Lasers, Ceramic Lasers, Efficiency, Laser Architectures

A06-209 TITLE: Dynamic Integrated Video/Virtual View (DIV3)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: To use multiple video sources, virtual (visual) databases, geospatial data sets, and frontline sensors to complement each other in an integrated fashion. This will allow the current and future force to see the battlefield in ways that were previously impossible, taking full advantage of available sensing platforms. The Dynamic Integrated Video/Virtual View (DIV3) will dynamically use the best available source of visual, command and control, and geospatial information to provide an enhanced battlefield view. For example, the DIV3 will enhance live video feeds in a manner comparable to a heads-up display (HUD) to show overlay symbology (e.g., a planned route or departure point), known or suspected unit locations, recent changes to the environment, and geospatial data such a river depth. This research will address the operational gaps such as Ability to Conduct Joint Urban Operations; Timeliness of Analysis and Information Dissemination; and Train the Force How and As it Fights.

DESCRIPTION: The Dynamic Integrated Video/Virtual View (DIV3) will provide enhanced situational awareness of the battlespace in terms of predictive analysis and decision-making techniques that will help the commander/operator estimate enemy courses of action and adaptively plan friendly actions. This effort will focus on a key enabling technology for DIV3, namely the ability to incorporate innovative technologies (tools & algorithms) for merging/fusing information from 7 major data sources: (1) live/stored video, (2) imagery (overhead, still pictures), (3) geographic information system (GIS) data, such as cultural features and attribution, (4) C4I data (overlay symbols, unit locations, etc.), (5) operator annotations & input, (6) mission planning systems, to include Computer Generated Forces applications used in training, and (7) changes between previously sensed data and newly acquired data (e.g., the sudden appearance of a crater on a road, or the destruction of a bridge). All of this information will be geo-referenced, integrated, and displayed as a mixture of video and virtual (computer-generated) images. The data fusion capabilities will be well-suited to use within an intuitive user interface, taking advantage of touch screens, motion sensors, voice commands, etc., to allow the observer to select the viewpoint and the nature of the enhanced information displayed.

The M&S Training and Operational communities have identified the lack of critical technologies, techniques, and algorithm and for merging/fusing information data sources to aid decision-making capabilities. To achieve these goals, DIV3 will require technology to merge these disparate data sources in real-time (or near real-time). This technology will also support the ability to detect and discretely identify changes to geospatial information based upon frontline sensors, whether overflight (UAV) or ground (UGV). Ground sensors could include human observation (data entry), photos, video, GPS data, or the proximity sensors of a UGV. Regardless of the source, the observed environment must be compared to pre-existing geospatial data, with detected changes being discretely identified, and then integrated back into the electronic terrain representations in a way that is clearly distinguishable to the human observer and underlying services (e.g. automated route planning).

A typical scenario for the use of the merging/fusing technology is to assist a future force soldier or an Future Combat System (FCS) operator to be able to select portions of the merged video/virtual display to gain additional information such as notes taken during mission rehearsal, detailed attribution such as the number of rooms in a building (if available), or links to alternative data sources (floor plans, map views, etc.). By using technology/algorithm to merge the information sources, the operator will be able to select variables such as projected weather, time of day, sensor in use, to wargame possible scenarios. This will allow the future force soldier to see the battlefield from an enemy's position (or likely position).

This technology could be used outside of military applications, such as automatically noticing faults in routing networks for applications like MapQuest, extending assisted-navigation applications to provide richly detailed, 3D directions with visually hi-lited routes, providing virtual reality tours for the tourism industry, and supporting police or security systems.

PHASE I: Conduct industry and technology surveys to determine the best starting points for merging/fusion technologies, including approaches for visualizing the merged data. Consider and document approaches for comparing sensed data to pre-existing data sets to identify and categorize changes, georeference such data against video sources, etc. Provide a report illustrating how continued research would be conducted, including a description of how the Phase I DIV3 data merge capability maps into FCS technologies.

PHASE II: Provide initial concepts on software algorithms to address merging and visualization of various sources. Provide a basic demonstration of selected DIV3 data merge and display capabilities as a proof of concept and describe an approach for a more complete implementation. Develop a prototype DIV3 capability targeted to key areas not addressed by existing or near-term technology. Provide a detailed demonstration of the resultant capability as it applies to the Future Combat System (FCS). Conduct experiments to evaluate usability from the standpoint of future force soldiers.

PHASE III: Broaden the implementation of DIV3 to a complete data merge and visualization capability ready for transition to targeted military applications. Include evaluation of applicability to commercial uses such as navigation systems, airport security, urban planning and emergency preparedness. Possible uses including automatically noticing faults in routing networks for applications like MapQuest, extending assisted-navigation applications to provide richly detailed, 3D directions with visually hi-lited routes, providing virtual reality tours for the tourism industry, and supporting police or security systems.

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KEYWORDS: Simulation, video, data fusion, situational awareness, battle space and command, situational awareness, battle command, synthetic natural environment (SNE)

A06-210 TITLE: Predictive Technologies for Simulation and Training

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: To fully utilize emerging predictive technology capabilities, design approaches to integrate or federate predictive technology with the One Semi-Automated Force Objective System (OneSAF) Objective System must be developed and evaluated. The development and fielding of predictive technologies (i.e., decision aides) and the associated training methods to increase their efficacy, are desperately needed by military Commanders and the civilian community (i.e., federal, local and state Governments).

DESCRIPTION: The terms predictive battlespace awareness (US Air Force) and predictive analysis (US Army) describe future decision-making techniques and technologies that will help the commander estimate enemy courses of action and adaptively plan friendly actions based on these estimates. Both communities have identified the lack of critical technologies, techniques, and decision-making tools to support such capabilities. Recent evaluations of the Defense Advanced Research Projects Agency (DARPA) Real-time Adversarial Intelligence and Decision-making (RAID) System indicate that the technologies being developed therein may produce a compelling tactical advantage in conventional, asymmetric, and Network Centric Warfare (NCW) contexts and a compelling cost savings in conducting large scale training exercises by providing a semi-automated Opposing Force (OPFOR). Exploration, development, and application of these types of predictive technologies (and associated training support tools and methods for individuals and teams) must be accelerated to meet known and emerging threat environments and the increased operational tempo now faced by the military services. Predictive technologies should also be developed to augment existing and future capabilities in sensor management, fusion, semi-autonomous control, air space management, the air task order development and execution process, effects based management and logistics operations.

PHASE I: The Phase I Study will produce a design to assess predictive technology integration with the OneSAF. The design activity will review possible integration or federation approaches to include; Distributed Interactive Simulation (DIS), High Level Architecture (HLA), the Simulation Objects Runtime Database (SORD) interface, and overwriting the OneSAF Command Agent for selected entities, such as battalion and brigade command posts. The design activity will result in a recommended approach based on an assessment of multiple design alternatives and requirements in the Training Exercise and Military Operations (TEMO), Reasearch Development and Acquisition (RDA), and Advanced Concpets and Requirements (ACR) domains. The design approach will also identify a key set of OPFOR tasks that would be semi-automated by a predictive technology as an initial demonstration or proof of concept. This design analysis will also be conducted to evaluate extensibility of predictive technology applications in other existing and future capability environments.

PHASE II: Using the preferred or selected design recommendation from Phase I, a prototype will be developed that will provide an initial component of a low-overhead driver for the OneSAF Objective System (OOS). Further technology development and application may take several paths; OOS analysis capabilities may be enhanced, improved threat modeling and OPFOR training capabilities (such as staff training toolkits that are needed by the Deputy Chief of Staff for Intelligence (DCSINT), could be prototyped within Phase 2 budget constraints. Sensor management planning, training and operational control techniques that reduce the number of required operators per system controlled, reduce operator workload, improve sensor effectiveness and in-operation control of Semi-autonomous systems would also be investigated. Limited prototypes of these capabilities could be prioritized and developed based on known high levels of interest, (e.g., Joint Forces Command, (JFCOM), Army Research Lab (ARL), US Army Aviation Applied Technology Directorate (AATD), US Army Aviation and Missile Research, Development and Engineering Command (AMRDEC), United States Navy and the Future Combat Systems (FCS) robotics communities).

PHASE III: These technologies also apply to: automated precision fires systems, autonomous systems control, manufacturing sytems that use robotics, scheduling systems, air traffic control and workload management systems, disaster relief and emergency responder applications at the Federal, state and local government levels. Potential technology applications also include, Homeland Security planning and operations using predictive analysis for threat response and course of action analysis.

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KEYWORDS: predictive analysis, predictive battlespace awareness, simulation and training, team training, semi-automated forces, semi-autonomous systems, toolkits, sensor management, sensor fusion, robotics, decision-making; Information Assurance; Seamless Communication; Modeling & Simulation Technology

A06-211 TITLE: Reusable Synthetic Tissue for Severe Trauma Training

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: To research and develop a method for providing highly realistic simulated, severely injured skin for use in training medics in front line care.

DESCRIPTION: Severe trauma caused to extremities produce major challenges to our front line medics. These wounds can include traumatic amputations to one or multiple limbs, severe facial trauma and severe shrapnel trauma to any region of the body. All of these wound types can cause fatalities within minutes from profuse blood loss. In addition to knowing the procedures for treating such severe casualties, medics also need familiarity with the appearance of these injuries so that they are mentally and psychologically prepared.

Currently the only method of training for severe trauma is through the use of live tissue (pigs and goats). There has been a mandate for years to eliminate the need for live tissue in medical training. This need will never be eliminated until the severe trauma tissue training issue is solved. There are multiple parts to providing a complete training environment for severe trauma, including bleeding, bone damage, tissue damage, sounds and smells. This topic addresses only the tissue, including the skin and possibly fat and muscle.

PHASE I: This is a 6 month effort to test the scientific, technical, and commercial merit and feasibility of using more realistic skin for training medics. Proposed work should research existing technologies, including Hollywood special effects, doll manufacturers, medical mannequin manufacturers, and etc. Skins need to be easily added to any commercial-off-the-shelf patient simulators. Solution could include inexpensive, disposable materials as a solution. This 6 month effort will also develop a test plan to explore the psychological impact of such realistic and potentially emotionally disturbing wounds.

PHASE II: During the 24 month prototype developmental effort, one concept for the more realistic skin would be further developed and tested with a variety of mannequins. Before a final design selection was made and throughout the development of this phase, user input would be solicited and training value will be evaluated using the test plan from Phase I.

PHASE III: Because medical treatment goes across the civilian and military markets, there would be a market for this training capability on the civilian side as well, specifically focused on Natural Disasters and Homeland Defense.

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KEYWORDS: Medical, Training, Severe Trauma

A06-212 TITLE: <u>Embedded Computer Generated Forces (CGF) Operator Control Unit (OCU)</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Develop an Operator Control Unit (OCU) for control of computer generated forces in a field environment in support of embedded training. The OCU must be limited to the hardware footprint expected of operational systems for the future dismounted Soldier. The OCU should be user friendly for soldier to operate as well as operate under the likely field conditions and be capable of satisfactorily controlling CGF such as the Army's Objective OneSAF (OOS) and/or state-of-the-art game engines supporting Army collective embedded training.

DESCRIPTION: The future direction of training is towards a fully embedded approach that permits Warfighters to conduct both training and mission rehearsal using their operational systems. The system must use the Soldier's operational equipment with no additional training specific hardware. Computer Generated Forces (CGF) typically generated by OOS or other state-of-the-art game engines provide and control the opposing and supporting friendly forces for this collective embedded training. Presently the CGF workstations at Army simulator training sites have been designed for operation by professional operators – not soldiers. In addition, the hardware footprint of these operator systems are significant and are well beyond what could be embedded into the fielded, deployable operational systems. Recent attempts to develop a CGF role-player concept for embedded training have not identified a satisfactory solution. This causes embedded training applications to use canned exercises or portable trailers that contain the CGF workstations. Neither of these solutions is desirable since they limit the usability and flexibility of embedded training systems. For Soldiers to control the CGF workstation functions in the field, the CGF user interfaces must function at a high level and be much simpler and more intuitive. This will likely necessitate the replacement of the execution matrices used in current CGFs with a Soldier-machine interface. The OCU must also be usable by soldiers under field conditions. The OCU must also operate on limited hardware footprints such as the Soldier's operational command and control display.

PHASE I: Conduct research into the design of a OCU for control of CGF for embedded training in a field environment. Investigate the user interfaces currently provided by current CGFs, popular game engines, robotic systems and interfaces planned for the Future Combat Systems. Investigate past attempts to improve the CGF user interfaces to identify areas where the interfaces could be improved to make CGF control more intuitive for Soldiers. Investigate the likely hardware footprint of future embedded systems to determine innovative hardware and interface alternatives. Investigate terrain database needs. Develop design of an embedded CGF OCU design concept.

PHASE II: Develop a prototype Embedded CGF OCU providing exercise role-player control for a platoon-level exercise. Identify a set of use cases for which this OCU would be applicable. Demonstrate this prototype using existing mounted and dismounted embedded training prototypes. Conduct testing to evaluate effectiveness and Soldier usability.

PHASE III: In addition to being used to support the transition of the Army to embedded training, spin-offs of this technology could be used by gaming and multiplayer on-line environments to role play characters.

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KEYWORDS: embedded simulation, embedded training, input devices, Computer Generated Forces, Semi-Automated Forces

A06-213 TITLE: Abrasion/Shatter Resistant Transparent Armor

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: To improve transparent armor in the areas of surface abrasion and shattering from impact.

DESCRIPTION: A common problem with transparent armor is its resistance to abrasion. Special procedures must be followed when cleaning ballistic glass to prevent scratching of the surface. Another problem is the ability of transparent armor to resist shattering when impacted by rocks or other projectiles, not bullets. The Army is looking for a way to reduce or eliminate both surface abrasion and shattering due to rock impact. The current standard ballistic glass will be tested to establish a baseline for both abrasion and rock impact. Test data accumulated will be used to establish a level of desired improvement. The end solution of this effort will be tested to the same protocol and compared to the baseline performance to determine if meets the desired level of improvement. This solution however must not degrade the transparency of the ballistic glass. Protective coating technologies, formulation, and manufacturing techniques shall be investigated.

PHASE I: Perform a design study addressing surface abrasion and shattering due to rock impact. This study should also investigate the ability to stop .50 cal and Improvised Explosive Device simulation 20 mm FSP. Develop an initial concept design of Abrasion/Shatter resistant transparent armor and present a paper solution at the completion of phase I effort. The presented paper solution shall model key elements of the of the initial concept design.

PHASE II: Current standard ballistic glass will be tested to establish a baseline for abrasion and shattering due to rock impact. The initial Phase I concept design will be finalized and validated through testing. Required Phase II deliverables will include 10 samples for testing. The samples will be tested for abrasion and shattering as well as ballistic stopping power. The accumulated test data will be compared against baseline test data to determine the level of improvement.

PHASE III: Abrasion/Shatter resistant transparent armor could be used in both the commercial and military market. There is a high demand for armored vehicles in the commercial market. For example armor bank trucks or VIP carriers.

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KEYWORDS: Transparent Armor, Ballistic Glass, Abrasion, Shattering

A06-214 TITLE: Ultra-Light Weight Energy Absorbing Armor

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop and demonstrate a practical ultra light weight energy absorbing armor solution for protecting the cargo area of tactical vehicles from small arms & mine/artillery threats and define a practical approach to the affordable manufacturing of such a material.

DESCRIPTION: The function of tactical vehicles is to transport troops and supplies to sustain military operations. For traditional force-on-force warfare, the battle front is well defined and the areas behind the lines of battle were usually safe for logistics operations by unarmored or lightly armored tactical vehicles. However, asymmetric warfare by gorilla or insurgent forces has opened wide the battle space, hence, requiring up-armoring of our tactical vehicles.

Because of the weight burden associated with traditional metallic armors and the cost burden of advance ceramic and composite armors, we are relegated to protecting only the crew cab of tactical vehicles. Although the soldier’s safety is of utmost priority, the lost of the unprotected cargo, though replaceable, does have significant logistics impact. Not only is there a financial lost, there is also a lost in time to re-deliver the supplies, especially if they are long lead items. If the delay affects the sustainment of vehicles, equipment, and/or soldiers, there would be a reduction in mission operational tempo. The soldiers are also exposed to increase risk by having to re-run the convoy mission.

Although there is value in protecting the cargo, this value needs to be balanced with the cost and weight required to protect the large cargo areas of tactical vehicles. Though preferred, the solution does not need to be rigid but must not deform more than 6” into the cargo area upon impact. Although the solution does not have to be fiber based, it must stop 7.62mm x 51 NATO ball rounds @ 2500fps and 0.50 cal FSPs (fragment simulating projectile) @ 3500fps at similar, if not reduced, areal densities as typical aramid fibers, such as Kevlar, or high performance polyethylene (HPPE) fibers, such as Spectra and Dyneema, but at reduced cost and without the inherent disadvantages of each of the fiber types. It must be resistant to abrasion, mold, wind flex, UV, & flame (i.e., Molotov cocktails) and maintain its strength in moisture as well as low & high temperatures (i.e., below freezing to extended solar loading). When integrated onto a vehicle, the protection kit must be sufficiently structurally sound to withstand the blast wave from a mine or IED event even if there are penetrations from overmatching fragments. The kit must be capable of being emplaced and removed by a 2 man crew within 30 minutes on an FMTV-sized vehicle with only Basic Issue Item (BII) tools.

PHASE I: Develop a concept for a low cost, ultra-light weight, energy absorbing armor concept where up to 6” displacement during ballistic impact is acceptable in order to relax design trade space in order to achieve a higher performance solution at reduced cost and weight as compared to current available light-weigh armors. A 36”x36” sample should be developed and submitted to the government for evaluation. The sample should include all necessary mounting and support hardware suitable for ballistic testing. An interim and final report is due at the end of the study. The reports shall describe the concept and how it addresses all the desired properties, defeat mechanism, estimated production cost, and include testing and modeling & simulation results at a sufficient level to gauge success if a Phase II was to be awarded.

PHASE II: Develop and demonstrate a complete prototype on the Stewart & Stevenson’s 2-1/2 ton Light Medium Tactical Vehicle (LMTV). A LMTV will be available at the Detroit Arsenal [Warren, MI] to aid the contractor in designing the form and fit of their prototype. Upon completion of the kit, the contractor shall install the kit onto a LMTV at the Detroit Arsenal and provide a demonstration. During the development, the contractor shall have up to three opportunities to qualify the material performance against the two threat munitions. The qualification shots shall be conducted at TARDEC at the government's expense using an approved military test procedure. The contractor is encouraged to evaluate their material performance throughout its development at either there own facility or at an independent testing company. After the demonstration, the prototype kit will be relocated onto a test fixture and blast tested against an IED under gov't expense. The technology is considered successful if it defeats all three threats (i.e., small arms fire and blast wave & fragmentation from IED).

The contractor is required to brief their approach during a kickoff meeting and provide monthly progress reports as well as two formal technical reports (interim & final). At a minimum, the reports must include an overall system description and highlight the innovations and benefits over the current light weight armor technologies, detail the armor stopping mechanism, detail the new material's manufacturing process or process improvements to the current process, estimate the production cost with rationale, discuss the test results and any modeling and simulation, and include installation and removal procedures for the LMTV kit.

PHASE III: If the prototype kit successfully defeats both threats (small arms and mine/artillery), the technology will be transferred to PEO CS&CSS for their consideration in their tactical vehicle fleet armoring strategy. If improved performance and cost savings are realized, this technology would be able to competitively compete not only in the military sector but also in the commercial sector for applications such as armored police cars, police bullet proof vests, ship ropes and fishing lines.

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KEYWORDS: Kevlar, Dyneema, Spectra, light weight armor, reduced weight, reduced cost, energy absorbing, tactical vehicle protection, survivability

A06-215 TITLE: Imaging Radar for Small Unmanned Ground Vehicles

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Integrate the output of inexpensive, low-power, radar sensors with that of higher resolution range imaging devices.

DESCRIPTION: The automotive industry is driving the research and development of inexpensive, low power radar systems. For example, a number of companies are now producing ultra-wideband (UWB) radars that may be appropriate for small (man-packable) unmanned ground vehicle (UGV) applications. We are interested in exploring innovative methods to produce range images using radar sensors and then fusing that information with the higher resolution range maps of other range imaging devices, such as laser, flash imaging, and stereovision sensors. The radar is expected to provide the capability to see through poor weather and foliage. While most range imaging devices typically show surface features, the addition of the radar will provide information about the interior structure of obstacles and terrain. We anticipate that the resulting enhanced depth maps will not only show surface structure, but also some measure of the density or hardness of the objects. The radar system should be low power (< 5 W), compact (< 3000 cc), inexpensive (< $5000), and have a range appropriate for small UGV's (> 10 m). Low probability of detection is desired, but of secondary importance. Items of interest include the radar system, a higher resolution range imaging system, and software for fusing the range maps, displaying an enhanced range map, and performing intelligent obstacle avoidance. The electromagnetic emissions of the system shall comply with all applicable laws and regulations. Concepts will be evaluated based on overall system performance, size, power requirements, cost, ruggedness and detectability.

PHASE I: Develop the initial design for the imaging system. Provide analysis demonstrating the potential performance of the system. Documentation of design tradeoffs, feasibility analysis, and regulatory compliance shall be required in the final report.

PHASE II: Complete the system design 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 and a user's guide and technical specifications for the prototype system. The imaging system will be attached to a UGV and the system performance shall be demonstrated in an outdoor environment.

PHASE III: Commercial applications include many UGV applications, such as security, inspection, hazardous waste monitoring, and law enforcement. Military applications include security, inspection, reconnaissance and surveillance.

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KEYWORDS: robotics, radar, ultra-wideband (UWB), range image, obstacle avoidance

A06-216 TITLE: Small Unmanned Inspection Vehicle with Manipulator Arm

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Development of a small, high-speed, highly-maneuverable unmanned ground vehicle (UGV) with a rudimentary manipulator.

DESCRIPTION: Small military robotic vehicles tend to fit into two classes, fast reconnaissance vehicles with at most a camera as a payload, or slow explosive ordinance disposal (EOD) vehicles with limited mobility and complex manipulators. The purpose of this project is to bridge the gap between the two and produce a vehicle that has a manipulator arm and is fast and mobile. One of the roles of this vehicle will be to quickly inspect a variety of suspect areas or objects. It is envisioned that the UGV will need to move objects around, turn objects over, dig into the soil to uncover objects, and/or impact objects. These operations should only require a rudimentary manipulator with one to three degrees of freedom. Many of the current UGV manipulators are complex and expensive, due to the rigors of their functions or the lack of maneuverability of the platform. This topic seeks to explore the interplay between the maneuverability of the platform and the manipulator degrees of freedom. To make up for the limitations of the rudimentary manipulator proposed for this topic, it is anticipated that the UGV will need to be highly maneuverable (e.g. omni-directional). In addition to having relatively fast travel speeds, the vehicle will need fine locomotion control when using the manipulator. This topic also seeks to explore alternative power plants, such as a JP-8 fueled hybrid electric system, since current battery technology may not be adequate for the extended missions and significant power outlays envisioned for this vehicle. The vehicle and manipulator should weigh less than 40 Kg, be capable of driving at 40 Kph, be capable of lifting a 5 Kg object, and have tele-operation capability. A low-cost variant (<$5000), with slightly lower performance specifications, is also of interest for use in situations where there is a high likelihood of encountering explosives.

PHASE I: Develop the initial design for the vehicle and manipulator. Provide modeling and/or analysis demonstrating the potential performance specifications of the system. Documentation of design tradeoffs and feasibility analysis shall be required in the final report.

PHASE II: Complete the vehicle design 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 and a user's guide and technical specifications for the prototype system. Vehicle performance shall be demonstrated in an outdoor environment.

PHASE III: Commercial applications include many UGV applications, such as security and inspection, hazardous waste monitoring, and law enforcement. Military applications include security, inspection and EOD.

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KEYWORDS: robotics, inspection, manipulator, hybrid electric

A06-217 TITLE: <u>Light-Activated Instant-Blackening Optical Material</u>

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 a material of good optical quality which under normal illumination conditions is over 50% transmissive throughout the visible spectrum, but when exposed to high intensity light (such as a laser pulse) will blacken instantly and prevent the light from being transmitted.

DESCRIPTION: In order to protect soldiers' eyes and other military sensors from potentially harmful laser radiation in the visible spectrum, it is necessary to develop materials which respond very quickly (in under a nanosecond) to block the transmission of harmful laser energy through optical systems. Materials research is key to achieving this goal. This topic solicits materials research to develop a light-activated instant-blocking optical material (solid, liquid, or gas; solid is preferred). This blackening may either be a permanent change, or may be reversible.

The material will most likely be incorporated into optical systems at an intermediate focal plane and must be applicable to wide field-of-view (FOV) and fast f-number optical systems. The material should have a high visible transmission under normal daylight illumination conditions (at least 50% transmissive throughout the visible spectrum) and in general be of good enough optical quality for inclusion in optical imaging systems (i.e., low haze, etc.). When exposed to high intensity light (such as a laser pulse), the material should blacken instantly (in less than one nanosecond). The material should also prevent the light from being transmitted through the optical system to the eye or sensor, for input energies above the damage threshold of the eye or sensor. The material's blackening response must be broadband, across the entire visible spectrum (400-700 nm). Materials that blacken via damage mechanisms (i.e., sacrificial materials) are expected, however, materials whose blackening is reversible will be considered. This solicitation is for new, innovative solutions, not simply incremental improvements upon broadly reported laser protection technologies such as carbon black liquid suspensions (CBS) and reverse saturable absorber (RSA) dyes.

PHASE I: Design/develop one or more candidate material systems for a light-absorbing, instant-blackening optical material and submit samples for pulsed laser irradiation testing. Phase I deliverables will be sample materials, intermediate progress reports, and final report.

PHASE II: Iteratively investigate new materials and/or refine the materials' composition and manufacturing processes to produce a series of prototype optical materials with continuously improving performance in terms of light-blocking capability under focused laser illumination, optical properties (i.e., haze, etc.) under normal (daylight) illumination, manufacturability, and environmental stability (e.g., minimization of optical property variations with temperature). Conduct laser irradiation, optical properties, and environmental testing of prototype materials. Develop and document preparation/manufacturing processes for these prototype materials. Phase II deliverables will include prototype materials, test data/reports, documented preparation/manufacturing procedures, progress reports, and final report.

PHASE III: Potential Phase III military applications include laser safety devices for eyes and sensors. Potential commercial applications include laboratory and medical laser safety devices, optical data storage, and optical switching.

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KEYWORDS: optical, laser, optical attenuation, scattering, absorption, optical damage

A06-218 TITLE: Alternative Power Source for Small Unmanned Ground Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop an alternative power source (APS) for Small Unmanned Ground Vehicles (SUGV's), consisting of a JP8 diesel powered hybrid electric system that will act as the primary power unit.

DESCRIPTION: Increased mission technology requirements create many power issues for robotic platforms, especially when operating during long missions. As technology matures, robots are taxed to carry additional electronics and sensors. The power requirements of an electrical drive, as well as the onboard electronics, limit the mission duration and capabilities significantly. An alternative power source is needed to increase the capability, performance, and reliability of small robotic systems. Currently, the power and propulsion systems of military SUGV's are strictly electric. This has many limitations with respect to battery power, such as recharge time, constant degradation in battery, supply availability, run time, and power output. The BB-series batteries are considered the standard military battery and, according to the U.S. Army Communications and Electronics Command (CECOM) [5], they are used for 92 current systems. Of the estimated three thousand robotic systems fielded through 2005, the majority use the BB-series form factor, either on the Operator Control Unit (OCU), or in the robotic platform. However, they are seldom used in both, due to high power needs. To alleviate current power limitations, innovations are needed in the power sources of SUGV's. Improvements to the source of power would provide a plug-and-play solution for enhanced robotic interoperability, promote dual-use applications across the other BB-series systems, and expand the realm of opportunity for other technologies. A state-of-the-art study was performed within the commercial sector and government offices (CERDEC, TARDEC). It was found that there are several auxiliary power unit systems that are close to the desired form-factor for the two APS categories in this topic. However, no systems were found that have a hybrid mode to allow for increased efficiency and backup power. The envisioned JP-8 diesel fuel hybrid system would improve SUGV operations by having an unattended restart, auxiliary power, increased power-to-weight ratio, reduced cost, and would address the limitations of existing electrically driven systems. The proposed system shall be capable of operating in a battery-only or in the optimized hybrid mode. A battery-only mode is important in the event the vehicle either runs out of diesel or exceeds a system limitation in a hostile or dangerous environment. The APS shall run on heavy JP-8 diesel fuel.

Two categories of power requirements are needed to cover the spectrum of both small and large SUGV classes: 1) 1.5 – 2.5 kW and 2) 250 W. Excluding the supplemental batteries and diesel storage space requirements, the APS portion of the 250 W system shall have similar dimensions and volume to three BB-series batteries: 3 x (4.40 x 2.45 x 5 in) (dimensions of both the BB-390, 4.9 Ah (0.118 kWh @ 24 V) and BB-2590, 6.2 Ah (0.181 kWh @ 24 V) batteries). Similarly, the APS portion of the 1.5 – 2.5 kW system shall be of comparable volume and dimensions to no more than eight BB-series batteries (i.e. dimensions of 4.4 x 9.8 x 10 in). The APS shall operate within reasonable noise, vibration and harshness (NVH) limits (e.g. 50 dB maximum at 50 meters) and field temperature constraints (-20 to 100 deg C). The APS should be in an isolated compartment and not interfere with the overall system. The following additional requirements must be met: 1) must maintain power during a roll, 2) use military standard BB-series battery connectors, 3) provide a clean reliable 12-24 volt +/- 0.2 V with electrical surge protection, 4) life expectancy of greater than 6,000 hours, 5) operating elevation of up to 2,500 meters, 6) rechargeable SINCGARS BB-series battery compatible (BB-390, BB-2590), and 7) have a threshold fuel consumption of 0.080 gal/kWh (250 W system) or 0.160 gal/kWh (1.5 – 2.5 kW system).

PHASE I: The contractor shall design a diesel powered hybrid electric system that is suitable to meet at least one of the power categories for robotic platforms (1.5 – 2.5 kW or 250 W). A final design report shall include cost estimates for prototype development and assessment of production and technology risks. The contractor shall provide an analysis comparing the new APS to existing robotic propulsion and energy sources (i.e. weight, power output, maximum run time, etc.). Modeling and simulation results or an extensive study analysis should be contained in the final report.

PHASE II: The contractor shall continue the work from Phase I to develop an APS implementation onto a system chosen during Phase I. This APS integration will include the control system for remote control. The contractor shall integrate the APS technology onto a currently fielded U.S. Army SUGV as provided by the Contractor Officer Representative (COR) as government furnished equipment (GFE). Final deliverables include the APS system, along with a final report detailing all activities in the project, including a user manual for the APS system.

PHASE III: The technology developed under this project can be applied to many small mobility platforms, both military and commercial (i.e. ODIS, CHAOS, Packbot, Talon, etc.). SUGV's have application not only for the military, but also for search and rescue, fire fighting, law enforcement and homeland security. The developed alternate power source could also be used for hand carried portable power applications in the military and commercial sectors.

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KEYWORDS: Robotics, hybrid, diesel, alternative power, SINCGARS, batteries

A06-219 TITLE: Novel High-speed, Reliable, Non-mechanical Optical Switch

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: High speed, highly reliable, non-mechanical optical switch for optical waveguide devices, optical networks, and optical computing.

DESCRIPTION: The research proposed here will lead to the development of a critical component to waveguide structures or arrays that have multiple inputs/outputs and will require precise switching between them. Optical switch research has been an ongoing effort for quite a few years now. Currently, the majority of optical switches are based on MEMS technology. These MEMS based optical switches pose certain problems mainly due to having mechanical moving parts; lifetime, reliability, control and switching speeds to name a few. The development of a non-mechanical switch will help solve some of these issues. Some switch performance requirements are: short switching times, low insertion losses, high extinction ratios and high switch-state stability. The optomechanical switches used in commercial communication systems are unacceptably slow and are also relatively bulky and heavy. Electro-optic switches are fast, but they have large insertion losses, and are temperature sensitive. Novel optical switches are desired, having switching times of the order of less than a microsecond, insertion losses below 1 dB and extinction ratios of 50 dB or better. The switching technology should be polarization-independent and temperature insensitive. Better than 10E8 switching cycles during the device lifetime should be achievable. Switching speeds should be in the range of nanoseconds. The optical switch proposed should also be capable of transmitting light from deep-UV to Infrared. Waveguide arrays that are capable of transmitting light in the deep-UV to Infrared region are of current interest for a variety of applications. This range can be used in applications for chemical analysis to be used in chemical and biological sensors, along with being able to analyze the condition of certain liquids such as performing oil analysis and hydraulic oil analysis to help predict failure. The development of the technology from this topic will help further miniaturize this technology offering a small, compact, low power, more reliable device that can be integrated into manned/un-manned vehicle systems.

PHASE I: Explore possible novel optical switching technologies with the potential to satisfy the above objectives. Perform analytical and experimental work to select best approach. The contractor shall design and prove the feasibility of the optical switch technology described above. Modeling and simulation tools should be used to optimize the design.

PHASE II: The contractor shall continue the work from Phase I to develop a fully packaged optical switch system. Depending upon the successes in Phase I, the delivered prototype system shall comprised of a single, double, or array of switches. The system shall demonstrate achievability of low insertion loss, high extinction ratio, lifetime and temperature insensitivity by a combination of analysis and laboratory experimentation.

PHASE III: The commercial market for such technology is nearly immeasurable. Extremely fast, reliable switch technology for optical networks could be widely used in DoD and commercial communications systems. All communication systems, optical networks, sensors, micro-based devices, medical devices and optical computing will benefit from this technology.

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KEYWORDS: Optical Switch, High Speed, Computing, Fiber Optic, Network, Microsystems

A06-220 TITLE: Innovative Shape Memory Materials Process Techniques for Microelectronic Device Packaging

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Improvement in the durability and reliability of the packaging of microelectronic devices, such as MicroElectroMechanical Systems (MEMS), through innovative processing of Shape Memory Materials (SMM).

DESCRIPTION: There are many well known traditional manufacturing techniques that are being applied to macro-level material processing; however these techniques have not been fully explored to study their applicability to the micro-level to improve the reliability and durability of micro-devices such as those made from SMM. It has been commonly realized that superfine-grained materials in sub-micrometer grain size have much improved performance and superplasticity as compared to that of regular grain size (in the range of 10-100 micrometer). Several breakthroughs in new materials (i.e. SMM) and processes, especially in nano-material processing, have been reported to have opened a new era in material refinement and high-strain-rate superplastic forming technology.

Since SMM have varying material selection, process, and manufacturing criteria when being applied to MEMS or microelectronic packaging, the study of self healing, self monitoring and having the ability to hinder crack propagation is also innovative, and has yet to be fully quantified on the micro-scale level. Research on SMM, their processing and manufacturing processes will result in a greater understanding of the physical/mechanical/electrical/thermal characteristics of the material. By gaining this knowledge, application of the material to microelectronic and MEMS devices will yield higher durability/reliability devices. The new innovative process proposed should improve on performance specifications of currently used processing techniques and address manufacturing cost trade-offs. Some environmental and performance factors that should be focused on during development and testing include (but not limited to): humidity, impact testing, mechanical shock, electromagnetic compatibility, and hermeticity. Certain specifications of the above factors include: humidity: 96 – 1000 hrs between 60 to 85°C with 85 to 90% relative humidity; impact tests consisting of 1 – 5 drops at 1 meter height with no performance degradation to the device; mechanical shock: 5g – 100g pulses at 10msec durations; electromagnetic compatibility: 50 – 200 V/m at 1 – 1000 MHz; and hermetic sealing: able to withstand pressures ranging from 15 – 250 kPa.

PHASE I: Phase I expectations and desired results shall consist of (but not limited to) preliminary research into various processing techniques for SMM (either Shape Memory Polymers or Shape Memory Alloys) that would be applied on a micro-level electronic packaged device. Additionally, recommendations for Phase II experimental work to be performed on the recommended material/material process should be included. The contractor, in accordance with the Contracting Officer's Representative (COR), shall also determine an appropriate device, such as a gyro, accelerometer, etc. to be used in phase II (if awarded) to be packaged with the material developed from the proposed process.

PHASE II: Phase II expectations and desired results shall consist of (but not limited to) fully developed research and development into a single material process utilizing SMM. End result will consist of a microelectronic device or MicroElectroMechanical System (MEMS) packaging material that will provide improvement for mechanical strengthening, humidity, impact testing, electromagnetic compatibility, and hermeticity. Material characterization tools should be used to examine the material processed. The device chosen and packaged with the material processed from this project should exceed the performance and environmental factors explained in the description. The contractor will work with the COR to develop a test plan for the fully packaged device. At the end of phase II, a fully packaged device, chosen in phase I, that is made from the material developed with the proposed processing technique along with a fully documented final technical report explaining the work completed in phase II.

PHASE III: The new materials process developed under this project has a large commercial potential. The integration of this research into current MicroElectroMechanical System (MEMS) devices will increase the durability/reliability that is required for military applications and is applicable to the commercial sector. Sensors, such as accelerometers, pressure sensors, gyros, etc. will benefit from this research. The military and commercial sector (automotive OEMs, Tier I suppliers, etc) will also benefit from this research.

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KEYWORDS: Equal Channel Angular Extrusion (ECAE), Shape Memory Polymers (SMP), Shape Memeory Alloys (SMA), Microelectromechanical Systems (MEMS), Packaging

A06-221 TITLE: <u>A Fast Portable Hyperspectral Camera for the Detection of Camouflaged Objects</u>

TECHNOLOGY AREAS: Electronics

0BJECTIVE: Design and build a hyperspectral camera that is portable and capable of ground-based operation, minimizes artifacts due to motion and weather conditions, and provides data relevant to camouflage detection.

DESCRIPTION: Hyperspectral cameras capture images of the world in spectral detail. Through these images one can learn not just the color of a surface, but also physical characteristics such as its material composition and temperature. These characteristics provide important clues as to the identities of objects, particularly when they are camouflaged in order to deceive human observers. While a number of satellite-based and aerial hyperspectral imaging platforms are currently in operation, the selection of available terrestrial cameras is limited. In particular, there is currently need for a portable broad-band (UV through IR) camera which can capture daylight hyperspectral images in less than one minute.

Interesting subjects of hyperspectral imaging, such as enemy troops and vehicles, do not typically remain still during data collection. In addition, weather conditions may induce the motion of foliage and other non-rigid objects. Motion creates types of artifacts in hyperspectral images which depend on the particular imaging system employed. They include erroneous object spectra which are hybrids between those of multiple surfaces, highly blurred images, and objects which are squeezed or elongated in the direction of motion. In order to minimize these effects, the shortest possible overall image capture period should be employed. This can be achieved by employing beam splitters to create multiple light paths for simultaneous capture of distinct wavelength bands by multiple imagers. Additionally, capture speed can be improved if only a subset of bands is desired. Therefore, a platform which offers programmable band and bandwidth selection would be advantageous.

A desirable hyperspectral camera which both minimizes these artifacts and provides data relevant to camouflage detection would have the following characteristics:
1. Portability: weight < 30lb, volume < 2 cu. ft., tripod mountable, external battery powered.
2. Image resolution: > 250,000 pixels total.
3. Spectral range: covering at least 280nm to 1000nm, with at least 40 separate bands.
4. Capture time: < 1 minute in moderate daylight.
5. MTF > 50% @ 35 line pairs per mm.
6. Distortion <12% over field.
7. View: at least 35 degree full angle of view horizontally and vertically.
8. Focus: from 2m to infinity.
9. Encode focus mechanisms to allow image metrology.
10. Motorized internals controllable remotely.
11. Programmable selection of number of spectral bands to capture and their center wavelengths.
12. Programmable selection of spectral image bandwidths (min. range 30nm to 70nm).

The camera would ideally be connected to a rugged notebook-sized computer with specialized software to both control the camera and capture/store images. Such software would allow live viewing of images and perform any geometrical transformations needed to correct distortions and bring images at different wavelengths into register.

PHASE I: Investigate current state of the art and conduct experiments to find potential design approaches. Create a technical report detailing the market and experimental results, and identifying the most promising design approaches.

PHASE II: Design and develop benchtop prototype optomechanical and image capture system using the most promising approach identified in Phase I. Evaluate ability to meet image capture specifications. Conduct testing to investigate deployability in outdoor environments.

PHASE III: The system would find applications in a variety of commercial applications, including scientific investigations and urban mapping, where artifacts are present, speedy imaging is valuable, and occlusion and camouflaging might occur.

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KEYWORDS: Hyperspectral cameras, hyperspectral imagery, spectrum analysis, multispectral, camouflage detection

A06-222 TITLE: Mobile Embedded Component Suite (MECS)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Create a widely available complementary suite of embedded Java components for resource-constrained devices. This component suite would address: (1) off-board message-based communications over a variety of potential communications channels, (2) command and response to off-board connected devices in a manner which provides hardware abstraction, and (3) graphical bitmap based human computer response and presentation. These frameworks shall be complemented by tooling plugins into a development environment such as Eclipse.

DESCRIPTION: There is an increasing need for fast deployment of reliable, smaller, mobile, occasionally connected devices for a wide variety of mission-critical applications. It is important that these resource constrained devices be able to connect easily and quickly to a variety of sensors and hardware, that they can present a graphical user interface that is easy to read and interact with, and that is capable of adaptive messaging amongst themselves and with remote legacy systems. To accomplish these goals, a Mobile Embedded Component Suite (MECS) comprised of complementary components and frameworks should be created. MECS consists of three modules. The first module is a hardware abstraction layer that abstracts the details of each hardware to software connection. Examples are different GPS devices, different data buses, and various other peripheral devices. Secondly, MECS consists of a very small, bitmap-based widget toolkit that is light on resource demands, simply effective in presentation, and speedy in response time. Finally, a messaging framework that gives quality of service and publish/subscribe functionality between nodes should be added to the suite. The frameworks shall plug into and make use of the Open Services Gateway initiative (OSGi) architecture.

A major focus of the development of MECS shall be to make the frameworks and tooling available to a large developer community. This would foster improvements and extensions that could be leveraged by the effort. Examples in the open-source community are prevalent.

Framework tooling shall be in the form of plugins to existing development environments such as Eclipse.

PHASE I: Phase I shall focus on the design and initial development of the three main components of MECS – the hardware abstraction layer framework, the light-weight bitmap-based widget toolkit, and the messaging framework for publish/subscribe functionality between nodes. Particular focus should be put on utilization of existing open source projects and frameworks where possible, and on ways to build the MECS framework in a way such that it can be built upon as easily as possible by a large developers' community. The primary objective of phase I should be generation of a design or model for the three frameworks using UML or some other graphical representation, supported by additional documentation.

PHASE II: Phase II shall utilize the work done in Phase I to deliver the frameworks, tooling, and documentation for the three main components of the MECS component suite. Functionality, flexibility, and ease-of-use of the created MECS suite shall be demonstrated using simple yet functional applications built on top of it. Specifically, successful use of the device abstraction, light-weight widget toolkit, and messaging framework components of MECS shall be demonstrated in a single cohesive application. Additionally, any tools developed to support use of the framework should be demonstrated. Pluggability, extensibility, and usability with existing open-source projects and development environments like Eclipse shall also be demonstrated.

The device abstraction component shall connect to at least two hardware devices to an application built upon the light-weight widget framework, and shall use the messaging framework for communication of information over at least two different communications transport layers.

PHASE III: MECS has applications in a variety of commercial and military devices. Development of an open framework for creating fast and reliable embedded applications would make the use of the MECS possible by a wide number of developers for a variety of applications. These include vehicles diagnostics applications which use the hardware abstraction layer to connect to vehicle devices (i.e., devices on the bus), use the messaging framework to reliably communicate diagnostic information back to other devices on or off the vehicle, and use the light-weight widget toolkit to display information on an in-vehicle, resource constrained device. Specifically tailored applications could be built for a variety of military and commercial devices using custom-built hardware abstraction layers to talk to the device and the widget framework to design custom graphical applications.

Revenue sources of the MECS could be realized through training, documentation, and development services.

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KEYWORDS: Java, Embedded Java, Software Framework, Hardware Abstraction, Light-weight widget Toolkit, Messaging Framework, Open Source

A06-223 TITLE: Development of Federated Enterprise Architecture Models for Lifecycle Knowledge Management

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: To research and develop open architecture based meta models for the representation and federated management of knowledge generated over the lifecycle of weapon systems.

DESCRIPTION: As weapons systems continue to be fielded well beyond their originally planned for lifespan, tremendous amounts of product knowledge are generated throughout the extended lifecycle. This knowledge tends to be unstructured and difficult to manage, search and retrieve because of the lack of domain specific knowledge abstraction meta models. The problem is further complicated because of the islands of product data that are distributed, disconnected and locked in proprietary vendor formats. The solution involves a federated approach, where loosely coupled systems connect through common gateways based on common business semantics and open standards [5]. This will involve the development of software that make use of new metamodels and new federated concepts commonly referred to as a Service-Oriented Architecture (SOA). SOA holds the promise of allowing totally disparate applications and systems to accurately and securely work together.

This research will include investigating the use of Service Oriented components interacting in a peer-based federated environment, using service provider interfaces based on widely accepted standards. Currently, there is no standards-based consensus on what specifically constitutes a Service Oriented Architecture [3]. Despite the lack of specific agreement, SOA is commonly referred to as an architectural paradigm for components of a system and interactions or patterns between them. These components offer a service that waits in a state of readiness. Other components invoke these services in compliance with a service contract [3]. The SOA provides the foundation for a federated framework that will enable the Army and their suppliers to function as a federated supply chain.

A federation framework mirrors the structure of the real world collaboration between independent businesses and largely autonomous working groups that make up a supply chain[2]. A federation implies a loosely coupled system distributed across the internet, where the members join or leave the federation without breaking it and where they function on their own using proprietary vendor applications when not part of a federation [1]. In this way, organizations take advantage of both their own culture and vendor systems that are maximized for their own internal processes, but allow themselves to come together with partners to retrieve, share and exchange product content throughout the lifecycle of a product. Federation implies that one has established a degree of interoperability among systems that enables a shared information area and provides a set of operations that can be initiated in a controlled fashion by one system operating on content that is in another system [4]. The advantage of this approach is that it can penetrate as many tiers of the supply chain as required, without imposing any specific workflow requirements on the part of the participants [5].

PHASE I: Research the feasibility of using an open architecture based meta model for the federated search, retrieval and exchange of knowledge generated throughout the product lifecycle. Study the use of standard meta models that support product knowledge used in the different phases of the product life cycle. Examine what it would take to search, retrieve and exchange content found for each of the phases of the product life cycle (concept, technology development, system development, production & deployment and operations and support).

PHASE II: An enterprise software system will be developed that will provide the capability to search, retrieve and exchange product in a federated environment accessing data generated throughout the product lifecycle. The product content being accessed may include system requirements, as-designed engineering data, as-built data, interactive electronics technical manuals as well as other unstructured content used to support the product during some aspect of its lifecycle. The enterprise software will allow the end user to search and find content across a federation of partners. The end users need the ability to search and retrieve appropriate content across these partners without specific knowledge of the systems used by those businesses. The software needs to allow the end user to both search and find content across these partner systems and retrieve the content across a federated framework. The software will allow for content to be filtered so that a company can protect their intellectual property and share only content intended for specific partners.

PHASE III: This technology has wide applications for both the Army and the private sector. Integrating the extended logistics supply chain is an issue that can be solved using this revolutionary new approach to managaing knowledge throughout the lifecycle. The Army Future Combat System is one example where this technology would be directly relevant.

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KEYWORDS: product lifecycle, service-oriented architecture, metamodels, federated architecture

A06-224 TITLE: Multi-Physics, Multi-scale Ground Vehicle Reliability Prediction

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Establish an innovative approach for and demonstrate methodology & modeling tools to accurately determine from physics-based first principles the reliability for components, sub-assemblies, and whole vehicles, using multiple failure modes including mechanical fatigue, thermal stress, and uncertainties in manufacturing and history.

DESCRIPTION: This SBIR will define and determine an innovative methodology and modeling tools for predicting reliability of ground vehicles in a multi-physics and multi-scale manner. This is to be a physics-based method, starting from first principles, and not heuristic based. Multi-scale means considering reliability from the material level up through components, sub-assemblies, all the way to full vehicles. ‘Multi-physics’ means considering reliability where failures are caused by fatigue, thermal stress, corrosion, erosion and other forms of degradation. It must also address issues of uncertainty or variability in manufacturing, materials, maintenance history and usage history. The product resulting from this research will enable managers and engineers to assess the predicted reliability at the whole vehicle level, under multiple failure modes. Variability in the actual manufacturing and history of a vehicle should be accounted for. Using such a tool, engineers, designers, and others could begin to optimize designs for reliability. The resulting methodology and tools will need to take into account mechanical fatigue and thermal stress, and the possible interaction of these two failure physics. It must consider real world uncertainties. It is desirable to have the analysis include corrosion, erosion and other forms of degradation as well. Two key areas are the interactions between different parts of the analysis, and scalability. For interactions, the analysis should show how effects in each physics modify failures in the other physics. Also, the analysis must show how failures at the lower scales drive failures at the higher scales. These are to be physics-based, from first principles, and not heuristic. The Army intends to run these analyses in the massively parallel environment of High Performance Computers (HPC). To leverage HPC resources the algorithms must be effectively scalable. Serious attention should be paid to the issue of how to parallelize the method.

This technology will analyze the reliability at scales ranging from materials and vehicle components through full vehicles. In this effort, the implementation and development of state-of-the-art tools for dealing with uncertainty and variation is essential. This SBIR would tie in closely with Army ground systems (and data sources) and could include real systems for case study. The intended vehicle system we will focus on for this effort is the HMMWV, as a case study. It is expected that such tools will easily save the Army millions of dollars in improved reliability & readiness and reduced Operation and Sustainment (O&S) costs for a variety of systems. This tool shall be used to optimize ground vehicle designs for reliability under a Reliability Based Design Optimization (RBDO) system.

PHASE I: Design a concept for required tools to accurately determine the reliability for individual vehicle components thru full vehicles in both mechanical fatigue and thermal stress. Such tools should be physics-based, not heuristic, and should include computer aided engineering software, reliability software, and software to assess mechanical fatigue and thermal stress. In addition, the phase one effort shall define and determine the feasibility of developing a methodology used to implement the identified tools to work in harmony, and consider the scalability and parallelizability of this methodology. Success criteria for a methodology should be defined.

PHASE II: Develop, demonstrate and validate the methodology, connections and apparatus required to integrate the tools identified in phase one to predict the reliability of a vehicle or sub-system while considering uncertainty or variability in manufacturing and history. Failures due to mechanical fatigue and thermal stress, with interactions between these two physics, must be captured. Incorporating additional physics of degradation is desirable. Demonstrate the completed methodology and tools for predicting reliability on examples ranging from components thru entire vehicle systems. In addition, validate that the methodology and tools can predict different failure modes for different physics, and demonstrate the developed system can predict interactions between different physics being used. Demonstrate the prototype system in accordance with the success criteria developed in phase one. Finally, demonstrate the scalability and parallelizability properties of the methodology used, showing how the size of the problems relates to computing resources required. It is anticipated that the HMMWV will be used as the case study for this phase.

PHASE III DUAL USE APPLICATIONS: The tools and methodologies developed will allow engineers, managers, and suppliers to analyze reliability in multiple physics modes and at multiple scales from component through vehicle. This technology can be used by the US Army, USMC, our Allies, vehicle OEM's and suppliers who produce ground, air, or sea vehicles, and anyone who wants to understand the reliability of vehicles.

REFERENCES:
1) TP Davis, “Science engineering and statistics”; Henry Ford technical Fellow for Quality Engineering; Ford Motor Co.; http://www.timdavis.co.uk/research.htm; August 2004.
2) Kokkolaras, M., Mourelatos, Z. P., and Papalambros, P. Y., "Design Optimization of Hierarchically Decomposed Multilevel System under Uncertainty", Proceedings of the ASME 2004 Design Engineering Technical Conferences, Salt Lake City, Utah, September 28 - October 2, 2004, DETC2004/DAC-57357.
3) Hartmanis, Juris, Stearns, Richard, "On the computational complexity of algorithms", Trans. Amer. Math. Soc. 117 (1965), 285-306.
4) TARDEC Public Website; http://tardec.army.mil/

KEYWORDS: Reliability, Scalability, Stochastic Modeling, Optimization, Prognostics, Diagnostics, Design under uncertainty, System Optimization, Reliability Based Design Optimization, RBDO

A06-225 TITLE: Advanced Fuel Injection System and Valve Train Technologies

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: To examine and develop combustion system 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 that 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. Vehicles are expected to operate in 125 F ambient conditions with significant solar radiation loading and a high concentration of airborne particles. Optimal diesel engine performance targets include minimization of heat rejection (< 25 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. Technology areas under consideration within this topic ARE LIMITED TO: (1) hydraulically actuated, high pressure, multi-pulse fuel injection and (2) hydraulically actuated and fully variable valve trains. An integrated fuel system – valve train approach is preferred in order to minimize parasitic losses. Success is dictated based on technological advancements made to improve future military diesel engines.

PHASE I: Contractors are expected to develop concept(s) using engineering analysis and also provide a representative bench top demonstration of any proposed concept(s).

PHASE II: Contractors are expected to integrate a final concept into an engine system and perform engine level testing and evaluation for assessing any claimed benefits derived to the military from the proposed concept.

PHASE III: Successful demonstration and development of a proposed concept potentially may be integrated into commercial heavy-duty and medium-duty diesel engines for application to military trucks and light combat vehicles. Such integration could lead to higher power density propulsion systems that may or may not meet current emission standards, but will provide optimal vehicle mobility to the soldier.

REFERENCES:
1) "Research Needed for More Compact Intermittent Combustion Propulsion Systems for Army Combat Vehicles", Volume 1, Executive Summary and Main Body, Southwest Research Institute, Interim Report TFLRF No. 296, Blue Ribbon Committee Report, 1995.

KEYWORDS: high pressure fuel injection, variable valve timing, high power density, diesel engine

A06-226 TITLE: Demonstrate Novel Techniques to Manufacture Advanced Complex Three-dimensional Fuel Injector Nozzle Shapes to Improve Combustion Efficiency and Reduce Emissions

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: This topic seeks to advance the state of the art of fuel injector fabrication, particularly with respect to producing fully three-dimensional small hole shapes in materials compatible with diesel fuel injection.

DESCRIPTION: Even in times of peace, the Army uses approximately 600,000 gallons of diesel fuel each day, and diesel fuel is about 40 percent of the tonnage of all material on the battlefield. The Army has a longstanding interest in improving diesel fuel economy through improved fuel injector nozzle design. The performance, efficiency and emissions of diesel engines are in part a function of the atomization of the fuel as it is injected into the cylinder. Greater atomization produces smaller droplets with more surface area, enhancing conversion of the fuel to the gaseous state, which increases combustion efficiency, cuts emissions and improves fuel economy. Reduction of soot is a major goal of reducing diesel emissions. Soot is the result of heterogeneous fuel distributions; it is formed in regions of the cylinder where the fuel/air ratio is excessive. Better fuel distribution in the cylinder reduces soot. Fuel atomization is improved by higher pressure, but it can also be enhanced by the geometry of the injector holes. The principal techniques of creating holes in injector nozzles are punching, Electric Discharge Machining (EDM), twist drilling, and laser machining. While the latter offers more flexibility in the shape of the injector holes, the hole geometries resulting from all these processes are still limited to shapes with straight walls or walls with varying tapers. Laser-drilled holes can be smaller than the standard EDM holes. Still, while the geometry of laser-drilled holes may include a range of shapes (circles, rectangles, ovals, etc.), and hole wall taper may change as a function of hole depth, laser machining in metal does not give full three-dimensional control of the hole geometry. Further, conventional laser machining brings its own problems; for example, damage to the back-wall of the hole when the laser beam breaks through the nozzle wall. While simple wall tapers may enhance atomization, it has been speculated that more complex wall geometries would help as well. Another potential benefit of better control of injector hole profiles could be the reduction in cavitation, resulting from the new high-pressure systems. Cavitation can reduce the performance, emission, and economy gains that result from the high-pressure injection systems, as well as to cause damage to injectors. Better nozzle wall shape control may also produce more homogenous fuel distribution within the cylinder, thus reducing soot.

PHASE I: The contractor shall design and prove the feasibility of a manufacturing process of diesel fuel injectors that will result in enhanced fuel atomization in diesel engines by enabling production of complex nozzle shapes beyond the simple straight-wall or tapered wall forms that are currently produced. Modeling and simulation tools should be used to optimize the design of the new fuel injector. The contractor shall also provide a cost analysis of having such a manufacturing technique of fuel injectors, including providing data on how the new fuel injectors will reduce emissions and improve fuel economy.

PHASE II: The contractor shall continue the work from Phase I to develop a system that will be capable of the advanced manufacturing of fuel injectors. Using this newly advanced process and the results of the models and simulations, the contractor shall fabricate multiple prototype fuel injectors with advanced fuel atomization capability. The prototypes shall be manufactured with varying nozzle shapes that will be tested to optimize the atomization of the fuel into the cylinder. The contractor shall demonstrate these novel fuel injectors fabricated with this new process in a diesel test bed. The contractor shall perform tests to prove the fuel injectors functionality and reliability. The contractor shall demonstrate the cost effectiveness of the fuel injector and its performance of improving fuel economy and reducing emissions.

PHASE III: This work also has value outside the Army as diesel fuel use by civilian trucks amounts to over 30 billion gallons yearly in the US, a number that will rise as more passenger vehicles are sold with diesel engines. This trend is driven by the 10-30% higher fuel efficiency of diesels over gasoline engines, improvements in diesel emissions and drivability, and good diesel engine durability. The technology developed under this project will be applicable to all engines, therefore having an extremely large market.

REFERENCES:
1) http://retrorebuild.com/fmmag/article_archives.asp?action=details&article_id=708

2) Clarke, Jo Ann, T.S. Givens, James T. Williamson, "Laser Drilling of Diesel Fuel Injector Nozzles," Lambda Highlights, June 2003, N. 62, pp. 4-5.

3) Rutterford, Graham, Dimitris Karnakis, Andrew Webb, Martyn Knowles, "Optimization of the Laser Drilling Process for Fuel Injection Components," Oxford Lasers report, 7 pages.

4) Knowles, M.R.H., A.I. Bell, G.R. Rutterford, A.J. Andrews, G. Foster-Turner, Andrew Kearsley, "Laser Drilling of Fuel Injection Components," Oxford Lasers report, 10 pages.

5) "Cavitation in a Diesel Fuel Injector," Fluent Application Brief EX200, www.fluent.com.

6) Van Gerpen, Jon, "The basics of diesel engines and diesel fuels," University of Idaho Department of Biological and Agricultural Engineering, Moscow, ID 83844.

KEYWORDS: Fuel, Injector, Diesel, Engines, Manufacturing, Laser

A06-227 TITLE: Leap-Ahead Air Filtration Innovations and Technologies

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The objective of this project is to develop Leap-Ahead Air Filtration Innovations and Technologies (LAAFIT). The technology of interest is a non barrier filter air cleaner design which can operate at: (1) high efficiency and (2) long service life intervals. The LAAFIT new air cleaner design must also consider weight, volume and power demands. Any new non barrier filter air cleaner design must be competitive in size and weight to current air cleaner design and consider the Army’s overall goal to make new propulsion components which enhance military vehicle developers desire to make vehicles more lightweight, compact and power and energy conscious.

DESCRIPTION: Non barrier filter air cleaner designs will be explored and developed which provide the maximum benefit to current Army high density military vehicle fleets such as the HMMWV. Currently all military and commercial vehicle systems use a barrier filter design as a secondary or final stage to trap contaminants from entering the engine. These barrier filters meet the Army’s requirement for high efficiency of 99.5 % and above but can result in short service life when vehicle systems are required to operate in dust regions of the world where fine dust/dirt is found. As a result high logistic support and maintenance costs are realized in replacing air filters. The removing and installation of these air filters also adds an increased risk of introducing dust/dirt into the air cleaner intake box.

There have been limited research development efforts on non barrier filter air cleaner system designs, which could provide an alternative approach to the 40 year old barrier filter technology. Some limited research efforts have or are focusing on electrostatic and multi stage inertial separators. Some recent electrostatic development has focused on commercial passenger car application but this is far different from a military environment. There has also been some development in multi stage inertial separators but high efficiency on fine dust is a concern. The challenge remains to design an air cleaner system with a non barrier filter which can meet the Army’s efficiency requirement of 99.5% and achieve a lab service life approaching 200 hours. Equally important will be to assure that the efficiency of 99.5% can be met whether the test dust is fine or coarse. All non barrier air cleaner design approaches in addition to the two previously discussed will be considered for this effort.

PHASE I: The contractor will become knowledgeable of military engine air filtration systems employed on military tactical wheeled and combat vehicles. The new innovative LAAFIT air cleaner design using a non barrier filter will undergo Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA) designs and studies to assure that the design concept is feasible, doable and can be substantiated through a working concept model. In addition, the contractor must have access to vehicle air cleaner drawings or a vehicle system to interface via early on form-fit-function integration. The air cleaner system using a non barrier design will also factor in the following technical parameters: (1) dust concentrations up to 20 times zero dust visibility, (2) a scavenging system design to remove dust from a first stage pre-cleaner if part of non barrier design and (3) scavenging blower motors development to remove dust from a multi stage inertial separator design or similar new design approach. Other factors include the operating environments which military vehicles are required to operate in. Current air cleaner performance specifications can be used as a guide for these operating environmental conditions which include items such as vibration, shock and ambient temperature ranges. The design chosen will also consider some flexibility for working off different platforms and have an objective to be a direct replacement or be able through spiral technology to transition into current vehicle filtration systems. At conclusion of Phase I the proof-of-principle must be demonstrated and preliminary predicted or actual test data be established to verify that objective goals of: (1) improved service life by a minimum factor of 2 over existing military vehicle barrier air cleaner designs with a desired goal of 200 hours while maintaining specified efficiency requirements when tested to MIL-PRF-46736 and/or MIL-PRF-62048C and (3) an initial economic analysis or cost benefit study to verify operational savings and cost reduction (OSCR) of the new design compared to current design.

PHASE II: In Phase II the contractor's non barrier air filter design will undergo a prototype design phase with continuing CFD and FEA efforts established in Phase I. The design prototype will undergo an initial design prototype build, factoring in material selection and ease of future manufacturing capability. Following construction of the prototype an initial operational verification check out will be performed. The design prototype will be carefully analyzed during test operations and be re-engineered and re-tested to certify that design up dates have achieved desired goals. In addition, material selection of filtration components in the non barrier air filter design will be analyzed and tradeoff analysis conducted following lab tests to determine the best material selection for design and manufacturing processes. Any changes to non barrier air cleaner prototype system will be extensively re-tested with the goal to harden the design for establishing: (1) if desired performance goals have been met and (2) a preliminary cost of the new air cleaner system. Concluding lab tests of the non barrier air cleaner system will assure that all performance requirements specified in MIL-PRF-46736 and MIL-PRF-62048 for vibration and ambient temperature ranges will have been met. If the non barrier air cleaner system prototype reaches a mature design, the contractor may test the prototype in a vehicle application to their choosing to demonstrate the next level of maturation. At completion of Phase II the contractor will deliver at least on (1) prototype.

PHASE III DUAL LEVEL APPLICATIONS: There are several commercial vehicles which use air cleaner systems similar to those in the military. One example is the M915 Family of Vehicles (FOV) which is used both commercially and in the military. Any new non barrier air cleaner system design would have application in this area since the air cleaner would be common to both the commercial and military sector. Cost savings realized from this new design concept would quickly transition to the commercial sector where pay back is quicker due to many more vehicle operating miles put on yearly. A similar case exists for the High Mobility Multipurpose Wheeled Vehicle (HMMWV) which is used by the Army and the H1 Hummer which is used in the commercial sector. The air cleaner systems for the HMMWV and H1 commercial Hummer are common.

REFERENCES:
1) Subject: MIL-PRF-46736E, Dated 21 August 1998, Performance Specification, Filter Element, Intake Air Cleaner: Dry Type.
2) Subject: MIL-PRF- 62048C (AT), 8 March 1996, Air Cleaners, Automotive: Heavy Duty, Dry-Type (For Internal Combustion Engines).

KEYWORDS: Filtration, non barrier, air filter, electrostatic air cleaner, multi stage inertial separator, air cleaner service life, efficiency, non barrier air cleaner and advanced filtration technologies

A06-228 TITLE: Research and Development Work to Optimize the Diesel Engine Design, to Operate at Greater than 42% Fuel Efficiency

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Research, and develop a compression-ignition engine design of a thermodynamics cycle capable of combustion near stoichiometric air/fuel ratio, and capable of operation with transiently variable compression ratio. The novel engine design is to reduce energy losses in partial load operation, and to have greater than 42% fuel efficiency at any power-road load condition. The engine performance is to meet a minimum power-density of 0.95 hp/lb of engine weight, and a minimum of 42 hp/cu ft of engine volume. The engine prototype demonstrator is to output a minimum of 650 hp in laboratory-dynamometer tests.

DESCRIPTION: Propose advanced technology compression-ignition engine designs incorporating a variable compression ratio and near stoichiometric air/fuel ratio. It is estimated that at any power-road load, the engine fuel efficiency would be greater than 42%, and with minimum power density of 0.95 hp/lb of engine weight, and a minimum of 42 hp/cu ft of total assembled and operating engine volume.

In addition to the stoichiometric combustion and variable compression ratio designs, the following advanced technologies and characteristics are to be included and integrated into the proposed engine.

* Controlled intake air boost (4.5 to 5.5 bars)

* Air boost cooling

* Electric or mechanical turbocharger drive for start-up and low engine speed operation.

* High pressure fuel injection of common rail design (25000-30000) psi

* Controlled air- fuel admissions for optimum engine performance.

* Advanced technology materials and coatings of engine parts

* Advanced technologies of tribology, friction, wear, lubrication and cooling

* Electric powered and controlled cooling system.

* Variable speed cooling blower.

* Variable valve timing

* Engine modeling and simulation codes are to be employed for optimization of engine design for best performance, durability, reliability, and cost.

PHASE I: Develop a physics-based analytical model of described engine concept. Validate through computer simulation the feasibility of the proposed engine. Validate via bench top hardware testing of key components.

PHASE II: Provide detailed analytical derivations and complete engineering design of proposed engine. Develop a full scale engine hardware prototype of the proposed engine concept and perform extensive testing of its performance and operating characteristics.

PHASE III: The novel technology of engine components and processes of Stoichiometric combustion, variable compression ratio, engine tribology lubrication and cooling system, coatings, and advanced engine cooling could become applicable on military and commercial future engine designs.

REFERENCES:
1. SAE paper no. 03P-227, benefits and challenges of variable compression ratio (VCR). Martyn Roberts. Prodrive Ltd

2. JR Clarke, RJ Tabaczynski, US Patent 6135086. 2000-10-24, Internal combustion engine with adjustable compression ratio and knock control

3. JE Brevick, US Patent 5755192, 1998-05-26, variable compression ratio piston

4. RG Sykes, Tickford, Engines Expo 2000 paper, methods to reduce the fuel consumption of gasoline engines

5. S Aoyama, H Fujimoto, K Moteki, European Patent 1170482, 2002-01-09, variable compression ratio mechanism of reciprocating internal combustion engine

6. J Beroff, European Patent 1143127, 2001-10-10, Internal combustion engine with variable capacity and compression ratio

7. G Rapan, I Rapan, Romanian Patent RO115662B. 2000-04-28, variable compression ratio engine

8. Real-Time nonlinear individual cylinder air-fuel ratio observer on a diesel engine test bench, Jonathan Chauvin, Philippe Moulin, Gilles Corde, Nicolas Petit, Pierre Rouchon,(Centre Automatique et systemes, Ecole des mines de Paris), (Institut Francais du Petrole).

9. Heywood, J. B. (1988) Internal Combustion Engine Fundamentals. McGraw-Hill, Inc.

10) Fantini, J and J. F. Burq (2003). Exhaust-intake manifold model for estimation of individual cylinder air-fuel ratio and diagnostic of sensor-injector. SAE Conference. (2003-01-1059)

11) Grizzle, J., K. Dobbins and J. Cook (1991). Individual cylinder air-fuel ratio with a single EGO sensor. Proc. in the IEEE Transactions on vehicular technology 40(1), 357-381.

12. Advanced Engine Technology
Heinz Heisler Head of Transport Studies, The College of NorthWest London, Willesden Center, London, UK.

13. SAAB Engine design with variable compression ratio

KEYWORDS: Advanced Diesel engine design, high fuel efficiency, stoichiometry, air/fuel ratio, transiently variable compression ratio, power density, road load, 1 hp/lb, 42 hp/cu ft, 650 rated hp, air boost, super-turbocharger, electronically controlled cooling system, variable speed cooling, high pressure fuel injection system, total engine efficiency, Engine tribology, engine coatings, engine prototype testing, military and commercial future engine designs

A06-229 TITLE: High Output Alternator Control System

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop a military compliant, reduced size, output controller for a permanent magnet alternator with high output.With this enabler, permanent magnet alternators, capable of creating high power outputs will be feasible for incorporation into existing (as well as new) vehicles, thus providing soldiers with the power needed to complete missions.

DESCRIPTION: Power out of permanent magnet alternator technology is a variable 3 phase AC voltage, proportional to alternator rpm and inversely proportional to current. The control receives this “wild” power from the alternator and delivers constant DC voltage at any current, up to a pre-determined current limit. Existing controllers are designed for commercial applications and are being built in limited quantities, primarily for large public transportation buses. This controller is approximately 6” x 12” x 16” (approximately 1200 cubic inches) and will delivery up to 300 amperes at 27.3 VDC into a nominal 24 volt battery system. Output ripple varies from 2% to 8%. In order to create an acceptable profile for incorporation into existing military vehicles, the controllers must reduce the ripple by two-thirds, while becoming small enough to "fit" into approximately 120 cubic inches (nominally 10 inches x 6 inches x 2 inches). The output current target which this controller should handle is 400 Amps at 28 Volts.

PHASE I: The proposer will: Investigate a minimum of two distinct control strategies. Analyze the alternatives for size, reliability, speed to market and capability. After down-selecting to one strategy, the successful proposer will design, construct and Alpha test a controller.

PHASE II: In Phase II, the offerer will build and test up to 10 units. Up to three of these will be mounted in vehicles for risk reduction durability testing. Up to seven will be tested in multiple load and usage conditions to validate output and reliability. The target testing will simulate 100,000 miles of run time (approx. 2,500 hrs.)and at extremes of temperature from -40 Deg. F to +130 Deg. F. The controllers must demonstrate capability to control current and maintain battery charge throughout this range and duration. The controller must also pass the Army specification for dust and water intrusion.

PHASE III: When commercialized, this system would provide any (internal combustion engine driven) vehicle with the power and voltage regulation required to optimize battery life. Additionally, the output of this alternator could provide the power to operate electrically driven accessories, either internal to the vehicle or external, such as consumer products like cell phones and entertainment products.

REFERENCES:
1) Argonne National Laboratory, article in Science Daily, 11-25-2005 and U.S. Dept. of Energy FreedomCAR & Vehicle Technologies Program article: "More Electric Truck Hits the Road".

KEYWORDS: Manufacturing Workforce, Electrical Power, Vehicle reliability, power control

A06-230 TITLE: <u>Magneto-Rheological Fluid Active Damper Suspension System for a Tracked Vehicle</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a Magneto-Rheological Fluid active damper suspension system for a tracked vehicle application.

DESCRIPTION: Magneto-Rheological fluids contain iron particles in a suspension of oil whose viscosity can change almost instantly with the introduction of a magnetic field. As the electric current varies, so does the suspension's damping resistance. This technology is ideal for the combat vehicle application due to its almost instantaneous response times, lack of cumbersome hydraulic plumbing, and robust nature. Presently, this technology is being tested on a wheeled combat vehicle application. To date, no efforts have been made to apply the MR fluid technology to a tracked vehicle application. Candidates will develop a MR fluid suspension system for a 20 ton tracked vehicle demonstrator using either a rotary or in-arm damper configuration (not a conventional linear external damper). The MR fluid suspension will improve ride quality, and cross country speeds. Future efforts will examine the possibility of incorporating a vehicle height control systems.

PHASE I: The SBIR would perform a detailed investigation to determine optimum configurations, verify the configurations performance through a tractive effort analysis and computer mobility modeling, down select to the most promising configuration.

PHASE II: Fabricate prototype hardware, and perform laboratory and vehicle testing.

PHASE III: Commercial development of Magneto-Rheological Fluid Active damping technologies (advancements) will correlate to advancements in MR damping reliability, performance, durability and capabilities, with respect to military vehicle applications.

REFERENCES:
1) Engineering Design Handbook, Automotive Series, Automotive Suspensions.....AMCP 706-356 (AMC Pamphlet).

KEYWORDS: Magneto-Rheological Fluid, MR Fluid, active damping, semiactive suspension

A06-231 TITLE: <u>Electric Drive Running Gear System</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: To develop an Electric Drive Running Gear System. The advent of hybrid electric drive with in-hub motors for propulsion has opened new and exciting drive system possibilities that were not possible with a conventional mechanical drive. The primary objective of this effort is to develop a track vehicle road arm with in-hub motor technology to allow mobility in the event of a track loss. However, this effort will also investigate other novel electric drive running gear configurations to accomplish the same objective.

DESCRIPTION: This SBIR will investigate the possibility of incorporating innovative electric drive technologies into the running gear to prevent a “mobility kill” if the track were lost. The SBIR must ensure that the selected configuration addresses integration with a 20-30 ton tracked vehicle with 5 or 6 wheel stations [e.g. FCS MGV,(Future Combat System Manned Ground Vehicles)].

PHASE I: The SBIR would perform a detailed investigation to determine optimal concepts/configurations, verify the configurations' performance through tractive effort analyses, computer mobility modeling and/or simulation. System trade-offs will be presented and a final recommendation will be characterized. This will constitute a down select.

PHASE II: The technology presented (in Phase I) will now be tailored to more specific requirements; these requirements will include dynamic loading, space and weight restrictions (supplied by RDEC sponsor), representative of actual vehicle integration. Engineering development of key prototype hardware will be documented and this phase will culminate in laboratory testing towards demonstration of "proof of concept".

PHASE III: Commercial development of drive motor technologies (advancements) will correlate to advancements in electric drive reliability, performance, durability and capabilities, with respect to military vehicle applications.

REFERENCES:
1) Engineering Design Handbook, Automotive Series, Automotive Suspensions.....AMCP 706-356 (AMC Pamphlet).

KEYWORDS: Propulsion, tracked suspension, electric drive, hub motors, running gear

A06-232 TITLE: <u>Shape Memory Alloy Reinforced Aluminum Foam composites for Ballistic Protection</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The objective of this SBIR program is to develop a methodology for designing shape memory alloy (SMA) reinforced aluminum foam metal matrix composite armor for the army applications in lightweight ballistic protection. Achieving this armor will improve the ballistic properties with the use of emerging smart materials, reduce the vulnerability of the vehicle and crew for ballistic impact and will result in a reduced structure weight compared to the existing ceramic composite armor materials.

DESCRIPTION: The aluminum matrix composites reinforced by SMA fibers have recently been processed with retained compressive stresses via the shape memory effect and has shown substantial increase in tensile properties, crack growth and fracture toughness [1, 2, 4]. NiTi/Al 6061 SiC composite, for example, absorbs impact energy 200 % more than monolithic aluminum 6061. The strong intermetallic bond has been successfully obtained through a proper powder metallurgy processing [2]. The use of SMA’s to aluminum matrix composite has shown unique properties such as self-strengthening by the compressive stresses in aluminum matrix due to the shape memory effect of the embedded smart material.

The concept of the design and manufacturing of SMA reinforced aluminum foam is proposed. The SMA reinforcing of the foam not only eliminates the problem of premature catastrophic failure due to excessive tensile or compressive stresses, but also an important role in energy absorption and shape recovery. Significant weight reduction is expected. Excellent stiffness-to-weight ratios of the foam composite combined with unique crash absorption capability [6, 7, 8], strength of reinforcement, and self-healability provide enormous potential applications of the SMA reinforced aluminum foam in lightweight load bearing structural parts, especially in ballistic armor.

PHASE I: Identify the most promising discontinuous SMA and silicon carbide particulate reinforcements. Investigate the various processing techniques to find a low cost manufacturing process for incorporating the SMA into the aluminum foam. Demonstrate the feasibility to produce the proposed composite armor having better ballistic properties together with lightweight than the advanced ceramic composite armor.

PHASE II: Develop analysis, modeling and simulation tools to optimize the SMA/Silicon carbide particles in the composite for the best interfacial properties, retained compressive stresses, impact toughness, dynamic energy absorption, and resistance to projectile penetration. Scale up the fabrication and assembly process for producing a prototype. Design, process, fabricate and test a representative metal matrix armor component for FCS vehicles. Validate the analytical results through laboratory tests.

PHASE III: The new SMA reinforced aluminum foam composite would be applicable to the Army ground vehicles as primary ballistic protection armor and also for add-on armor to increase the protection of existing vehicles. Dual use applications include in the armored cars for counter-terrorism protection, VIP vehicles protection and to protect both civilian and government buildings against grenades explosions.

REFERENCES:
1) Xie, C. L., M. Hailat, Z. Abedin, X. Wu, G. Newaz, M. Taya, and B. B. Raju, “Effect of NiTi short fiber SMA on mechanical properties of NiTi/AL 6061 composite,” 2005 SAE World congress, Detroit, MI April 2005.
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KEYWORDS: Aluminum foams, shape memory alloy (SMA), silicon carbide, ballistics, lightweight, energy absorption

A06-233 TITLE: <u>Advanced Military Cooling Designs and Techniques(AMCDAT)</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: To research and develop cooling system design technologies that will increase cooling performance while reducing component sizes and weight in military combat/tactical vehicles that are required to operate over a wide range of environmental extremes, both on- and off-road mission profiles, worldwide theaters of operation, and need minimal maintenance during combat operation. In addition, the cooling components, especially the fan, need to be able to operate in high temperature conditions inside the vehicle. This technology will benefit new vehicle designs such as the Program Manager Future Combat System (Brigade Combat Team) and/or be spiraled into existing vehicle systems where a need exists.

DESCRIPTION: The state of the art conventional liquid-cooling system consists of the engine radiator, radiator hoses, coolant thermostat, coolant pump, cooling fan and fan belts. These cooling systems perform in corrosive battlefield atmospheres where they come in contact with a variety of ground obstacles and vegetation that might damage cooling system components. Airside clogging of air-cooled heat exchangers with debris, mud, dust, dirt, sand, vegetation, ice, and snow is an ongoing threat to a cooling systems performance. Ambient temperature extremes for full power and/or maximum cooling system heat load operation are as high as 120 degree F and as low as -25 degree F without kits and -60 degree F with kits. These temperatures do not consider recirculation of discharged cooling air or exhaust, which can increase typical cooling-air temperatures 10 to 35 degree F above ambient and induction-air temperatures 15 to 50 degree F above ambient. The current military coolant is 50/50 mix of water/ethylene glycol. The radiator top tank coolant temperature should not exceed 230 degree F (except when specified otherwise) with the ambient temperature at 120 degree F. Some additional technical parameters of the current cooling system includes being able to remove entrained air at a rate equal to that specified by the engine manufacturer or 0.1 CFM per cylinder (which ever is higher) and having the capability of being filled at a constant rate in a 5-minute period to 90 percent of the cooling system capacity.

Today new military vehicles must be light weight, smaller size and provide enhanced mobility goals such as increased agility and speed. This requires that the propulsion compartment and cooling components be tailored and modularized for maximum weight savings and volume optimization. Recent and ongoing work include micro channel heat exchanger panels, all plastic radiator and two phase flow devices.

The innovative components will be designed, developed and evaluated through lab tests to verify that improved performance is obtainable. Improved performance of a modular cooling system component can translate into reduced weight and or smaller space/volume utilization. Other ways to reduce weight is to develop cooling components that utilize composite or plastic type materials. Weight savings of up to 25 percent for cooling components such as radiators or charge air coolers will be developed and verified by test, demonstrating they can meet performance requirements. Cooling system component development will also strive to obtain a reduction in a vehicle’s maximum cooling temperatures currently specified for engine coolant, engine oil and transmission oil. Reduction in these temperatures will result in improved vehicle reliability and reduced vehicle maintenance which is another driving force in this development effort.

In addition, these propulsion system components such as cooling fans must operate in the high temperature environment (300oF or higher) inside the vehicle. One technical challenge for the Manned Ground Vehicle (MGV) under the Future Combat System (FCS) Program is to provide a cooling fan which is capable of operating in this high temperature environment. Solutions to these real issues are critical, as related to new vehicles such as the Manned Ground Vehicle, if the Future Combat System Program is to achieve the desired performance goals.

PHASE I: In Phase I, the Contractor will baseline a current cooling system for a selected military vehicle. The new proposed cooling system component or technique will be designed and developed to provide higher performance, lighter weight, smaller size and/or fan operation in higher temperatures than baseline technology. The contractor must consider military environments and performance specifications. The proposed cooling concept must be able to fit within the tight volume constraints of existing cooling components. The contractor will establish a preliminary design of the new cooling system component or technique. A model will be developed and optimized for performance, size, and weight. Preliminary performance analysis of the model and initial lab evaluation will be use to demonstrate improved performance characteristics, compatibility and commonality with current vehicle cooling systems. Design goal will be to provide a new cooling system component or technique that is adaptable, flexible and provides commonality with current vehicle cooling systems. A successful Phase I SBIR contract will present substantial evidence which verifies that their newly developed cooling component or technique will obtain the objectives of higher performance, lighter weight and/or more effective cooling systems.

PHASE II: In Phase II, the new cooling system component or technique will be built and tested to validate its improved performance in a laboratory environment. The contractor will continue to harden the selected design concept by making design improvements in the areas of performance, size and weight. The prototype will be upgraded and lab testing will be continued until the prototype can demonstrate better performance, smaller size, and/or reduced weight than the production component it is replacing. The effectiveness and technical capabilities of the Phase II prototype will be verified through lab tests and assessed by technical experts in the field. The cost of the component or technique will be defined and any potential improvement technologies will be identified. A producibility study will be performed. At the conclusion of Phase II, the contractor will deliver at least one prototype cooling component or technique.

PHASE III: The development of a cooling system component or technique that demonstrates the ability to increase the effectiveness, performance and reduce the weight of an engine cooling system will be directly applicable to both the military and commercial sector.

REFERENCES:

1) Cooling System Design Guide for Military Vehicles, U.S. Army Tank Automotive Command.

These references are open source and are available to all potential proposal submitters.

KEYWORDS: Engine Cooling Systems, Radiators, fans, high temperature fan motors, fan clutches, heat exchangers/charge air coolers(oil to water, air to water, oil to air, and air to air), shrouds, thermostats, water pumps, hoses/clamps, compact modular radiators

A06-234 TITLE: <u>Piezoelectric Materials to Control Noise and Vibration and Detect Damage in ArmyGround Vehicles</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The objective of this SBIR program is to develop innovative structural concepts that would improve the performance and durability of the Army vehicles and or improve troop comfort through noise and vibration control using piezoelectric sensors.

DESCRIPTION: A typical Army ground vehicle contains several panel like structures, which have multiple functionality such as protecting the soldiers and being the structural members of the vehicle. Smart materials can be integrated into the vehicle skin to add additional functionality, such as sensing damage, actuation for noise reduction and communications for integrated antennas. A proper optimization of the material has to be made so that each function can be accomplished without compromising functionality and structural integrity. For example interior noise has been identified as one of the key factors that contribute to fatigue of soldiers due to the constant booming noise caused by the cavity of the vehicle and the radiating panels of the structure. Methods for reducing such noise controls may include either active or passive noise or vibration control. The advantage of active control is that higher vibration and noise reduction can be achieved. The advantage of passive control is that it does not require external power. Similar approaches have been used for engine noise.

PHASE I: A concept using smart materials should be developed to control noise, vibration and damage detection and its feasibility should be demonstrated. This concept should address both active and passive noise and vibration control or a combination of the two using piezoelectric materials. This concept should be related to a current or future army ground vehicle and should be technically sound. A path to actual implementation and production has to be studied.

PHASE II: The analysis, modeling and simulation tools should be developed to design vehicle structures for vibration and noise control using piezoelectric sensors. The concept developed in Phase I should be prototyped, tested and integrated into an Army ground vehicle. The final prototype should be tested and evaluated using actual driving and operating conditions. Both the actuators, sensors electronics should be powered using conventional 12 Volt automotive power supply and demonstrated on a typical Army vehicle.

PHASE III: This program supports the Tactical Wheeled Vehicle Modernization Strategy. The Phase III program will extend the design of such concepts to cover the manufacturability, cost issues, durability concepts. These concepts should have direct benefits to the U. S. Army ground vehicles. The dual use application in the commercial sector will include increased comfort for the automotive and transportation industry along with reducing weight and fuel consumption. The developed concept should bring benefits to the Army in the form of fuel efficiency, pollution reduction, and increased performance including durability, damage detection and comfort to the soldiers due noise and vibration reduction.

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KEYWORDS: Piezoelectric materials, smart structures, fuel efficiency, noise and vibration control

A06-235 TITLE: Army Tactical Wheeled Vehicle Emulator for Improved Simulation Characterization and Reliability Assessment

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Research and development is required to further investigate the vehicle dynamic simulation capabilities of the U.S. Army Ground Vehicle Simulation Laboratory on Stryker-type vehicles (i.e., multiple axle vehicles). Currently, the GVSL utilizes tire-coupled full vehicle simulation equipment (i.e. linear actuators with fixed platens). The U.S. Army needs to expand their vehicle dynamic simulation capability to include hub-coupled experiments, to further isolate the unsprung mass, and minimize variability in their experiments. By isolating the unsprung mass, simulation experiments will be able to provide a higher level of accuracy of the road profiles into the response of the simulator. By achieving this, the GVSL will be able to provide their customer with broader simulation capability to encompass the vehicle development spectrum, including durability, safety, performance, drivetrain, and noise and vibration. Lastly, the GVSL plans to utilize the SBIR Phase II to deliver a Stryker-type Hub fixture to accommodate lighter vehicles (i.e., HMMWVs).

DESCRIPTION: The GVSL currently utilizes tire-coupled simulation equipment. The GVSL is required to maintain state-of-the-art capability, and procuring a research and development fixture to investigate the loads seen at the vehicle hub would be instrumental in achieving this capability. These loads are crucial to developing analytical vehicle dynamics models, tire models, and subcomponent models. Similarly, physical durability testing can utilize this fixture to achieve higher duty-life cycles from the components.

PHASE I: Phase I expectations are to research current simulation capabilities of military vehicles and their limitations. Recommendations of design of an adaptable hub fixture to simulate ground inputs into military type vehicles.

PHASE II: Phase II expectations are to deliver a prototype adaptable hub fixture for improved military ground vehicle simulation. Developmental testing will be required in Phase II, and design modifications and optimization will be required.

PHASE III: Phase III expectations are to partner with the Army, and commercial private industry to commercialize this technology. Currently, technology of this advancement does not exist. Heavy duty trucking, and Heavy duty equipment industries would benefit from this innovative research.

REFERENCES:
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TITLE: Fundamentals of Vehicle Dynamics
AUTHOR: Thomas D. Gillespie
PUBLISHER: SAE International

YEAR: 1992
ISBN: 1560911999

2)
TITLE: Race Car Vehicle Dynamics
AUTHOR: William F. Milliken & Douglas L. Milliken
PUBLISHER: SAE International
YEAR: 1995
ISBN: 1560915269

3)
TITLE: Tires, Suspension, and Handling
AUTHOR: John C. Dixon
PUBLISHER: SAE International
YEAR: 1996
ISBN: 1560918314

KEYWORDS: simulator, fixture, adaptable hub, military vehicle testing, testing

A06-236 TITLE: In-Line Toxicity Monitoring for Maintaining Integrity of Potable Water Supplies

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Provide the 92W tactical water purification system operators, a tool to ensure the water leaving the reverse osmosis treatment stage, the granular activated carbon (GAC) column, and the ion exchange column is meeting system specifications and is safe for their fellow soldier to drink. This presumptive field test would provide a warning indication that warrants further analysis by off-line (discrete) qualitative and quantitative analytical devices.

DESCRIPTION: Provide the 92W tactical water purification system operators, a tool to ensure the water leaving the reverse osmosis treatment stage, the granular activated carbon (GAC) column, and the ion exchange column is meeting system specifications and is safe for their fellow soldier to drink. This presumptive field test would provide a warning indication that warrants further analysis by off-line (discrete) qualitative and quantitative analytical devices.

The 1500 GPH TWPS and LWP are mobile water purification systems consisting of the following unit processes: screening; coagulation; membrane filtration; reverse osmosis (RO); and chlorine disinfection. RO is the best available technology for the military requirement; however, it is known that certain contaminates are poorly removed by reverse osmosis and depending on the source water concentration may not be removed down to safe drinking water levels. Ion Exchange and granular activated carbon (GAC) processes are available to polish the RO product water when the source water is known to be contaminated with NBC threats.

GAC was selected based upon its proven effectiveness for the removal of chemical agents from reverse osmosis permeate streams. However, depending on the characteristics of the water that the GAC comes into contact with it has the potential to reduce taste and odors, remove toxic industrial chemicals (TICs), adsorb Disinfection By-Product (DBP) precursors (Tri-halomethanes), and also reduce actual disinfection by-products if present. The capability to remove a broad spectrum of contaminants has both positive and negative aspects. The advantage is that it can be used in numerous roles to remove a wide variety of contaminants likely to be encountered in field operations. The disadvantage is that there is undesirable competition for adsorption sites needed for the removal of the more lethal nerve agents the column was intended for. The standard practice used for developing the design criteria for the GAC column was based on single component test data which is not a good predictor for complex organic mixtures in natural waters. The data was also based on batch testing rather than flow through column testing. Therefore, good design practices with respect to column size, shape, loading rate, and a safety factor were used to determine a hard time interval change. This was the best approach that could be provided to ensure safe drinking water levels were met when the systems were developed. This procedure has unfavorable risk and cost elements that can be reduced or eliminated by advances in analytical technology.

The Petroleum and Water Business Area (P&WBA), RDECOM is the material developer for the Water Quality Analysis Set Purification (WQSAS-P). The water quality parameters monitored are pH, temperature, turbidity, total dissolved solids, and free chlorine residual (these are common place and easily monitored by commercially available meters). The P&WBA is currently evaluating Total Organic Carbon (TOC) as a surrogate to monitor the effluent from the activated carbon column for the presence of breakthrough as an intermediate solution. The organic carbon in water however is composed of a variety of organic contaminant and is not class specific. The goal of this project is to develop a detection platform that can identify classes of compounds in reverse osmosis treated water as follows 1) total nerve agents and their hydrolysis products at a level of detection of 0.004 mg/L 2) Toxic industrial chemicals such as organophosphates (malathion) and pesticides (lindane, etc.). This system will be a warning to the operator that more detailed analysis of the water is needed to ensure potability standards are being met. This system must be able to operate continuously in-line generating results every five minutes. Manufacturability of system must be in mass-production quantities, using mass-production techniques, for an end item price that is viable in the commercial market, with an ultimate product that could be produced for no more than $20,000 per copy.

This technology will provide the capability to assess the performance and breakthrough of granular activated carbon (GAC) columns used in tactical water purification systems.

The development of an in-line monitor to identify when to initiate the GAC column treatment process and determine when the column has reached breakthrough would provide a significant upgraded capability to the soldiers operating tactical water purification systems in the field. Although the main focus of this research and development program is to develop an in-line GAC column monitor, the analysis tool developed will also form the basis of a monitoring system that provides a number of additional applications. These applications include continuous on-line monitoring for other treatment processes, the distribution system, large volume storage tanks, and mobile tanks such as the CAMEL and the HIPPO.

PHASE I: Demonstrate concept feasibility by designing, building, and testing one breadboard system in a laboratory environment for the detection of one class of compounds. Demonstrate efficacy through Receiver Operational Characteristic (ROC) curve analysis.

PHASE II: Test breadboard system for identification of other classes of compounds that represent toxic industrial chemicals referenced in Tech Guide 230, to be determined by U.S. Army. Develop, build, and evaluate field prototype in-line monitoring device to monitor the performance of the GAC column for breakthrough of contaminants in field environment through third party testing. Demonstrate efficacy through Receiver Operational Characteristic (ROC) curve analysis.

PHASE III: Technology under this SBIR could be used at municipal/military water treatment plants as a trigger to determine a breach in treatment efficacy before non-potable water reaches the public. This technology could also be used in conjunction with water provided to a military installation to ensure the integrity of the water is maintained.

REFERENCES:
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2) U.S. Environmental Protection Agency (EPA), HTTP://www.epa.gov/water.
3) Bender, Doug and Bevilacqua, "Portable Continuous TOC Monitoring in a Semiconductor Water System".
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KEYWORDS: water, contamination, GAC, in-line, monitoring

A06-237 TITLE: Pollution Control Technologies Tolerant of JP-8 and other High Sulfur Fuels

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop or modify pollution control devices equipped on diesel engines designed to operate on ultra low sulfur diesel (ULSD) so they may operate effectively on high sulfur fuels, such as JP-8, and blends of high sulfur fuels with ultra low sulfur diesel (ULSD) and Fischer-Tropsch (F-T) diesel/jet fuel.

DESCRIPTION: High efficiency catalytic exhaust emissions control devices are being integrated into diesel engines to comply with 2007 heavy-duty engine regulations and on-highway emission standards. These control devices are intolerant of high sulfur fuels such as JP-8. Advanced pollution control technologies and catalysts were developed to tolerate ultra low sulfur diesel (ULSD) sulfur concentrations of 15 parts per million. However, military vehicles may be exposed to both sulfur concentration extremes: high sulfur fuels ranging in concentration from 3000 parts per million (maximum for JP-8; 10,000 ppm maximum for F-76) and, depending on the availability/logistics, low/zero sulfur fuels including ultra low sulfur diesel (ULSD) and Fischer-Tropsch (F-T) diesel/jet fuel. Furthermore, military ground vehicles may be exposed to blends of high/low/zero sulfur fuels as they are forced to refuel or top-off at numerous fuel stations carrying various types of fuel. Under this scenario, sulfur intolerant pollution control devices, and the advanced diesel engine technology they enable, would be disabled and likely result in engine failure. In order to ensure vehicle reliability/deployability and realize emission benefits, pollution control devices tolerant and compatible with high/low/zero sulfur fuels are required.

This project will focus on the development of pollution control technologies and devices tailored to reduce emissions of high sulfur fuels and blends of high sulfur fuels with ultra low sulfur diesel (ULSD) and Fischer-Tropsch (F-T) diesel/jet fuel. The project shall evaluate the material compatibility effect when using a range of high/low/zero sulfur fuel blends to ensure fuel interchangeability is maintained. A broad range of pollution control technologies tolerant of high sulfur will be considered excluding fuel additive technology

PHASE I: Conduct a feasibility study to determine the sulfur-tolerance of pollution control technologies capable of reducing total hydrocarbon (HC), carbon monoxide (CO), nitrogen oxide (NOx), and particulate matter (PM) emissions significantly and simultaneously. Sulfur-tolerance target shall exceed 3000 ppm sulfur concentration. Assess the material compatibility (i.e. catalyst functionality, elastomer swell) for high/low/zero sulfur concentration fuel blends to ensure fuel interchangeability. The results of the preliminary study will define the activities to be conducted in Phase II.

PHASE II: Utilizing the pollution control technology (or technologies) demonstrated in Phase I, perform pilot laboratory reactions to show ability to reduce total hydrocarbon (HC), carbon monoxide (CO), nitrogen oxide (NOx), and particulate matter (PM) emissions significantly and simultaneously when using high/low/zero sulfur concentration fuel blends. An ultra low sulfur diesel (ULSD) or Fischer-Tropsch (F-T) diesel/jet fuel shall be used as the baseline emission performance standard. High sulfur JP-8 and a mid-range sulfur fuel consisting of a blend of the low and high sulfur fuel shall be used as test fuels. Propose a procedure to implement technology in military ground vehicles (installation, retrofit, etc.).

Validate material compatibility of components using switch-loading techniques.

PHASE III: Pollution control technologies capable of effectively operating on high, middle, and low range sulfur fuels will enable the military to reduce emissions without jeopardizing reliability or operational readiness. The pollution control technology could potentially be retrofitted into the existing diesel and marine-diesel engine fleet and implemented into future procurements. The commercial industry may apply this technology to reduce off-road diesel engine, marine-diesel engine, and power plant emissions, which consume high sulfur diesel fuels. Furthermore, the development of sulfur-tolerant catalysts may lead to advancements in catalytic reformers, desulfation, JP-8 reforming technology, and sulfur-tolerant fuel cells.

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1) Yost, D. M.; Frame, E. A.; “HMMWV Field Operation and Data Collection and Analysis”, Contract No. DAAE-07-99-C-L053, Southwest Research Institute, Fuels and Lubricants Technology Department, December 2004.
2) Yost, D. M.; Montalvo, D. A.; “Comparison of Diesel Exhaust Emissions Using JP-8 and Low-Sulfur Diesel Fuel”, Contract No. DAAK70-92-C-0059, Southwest Research Institute, Fuels and Lubricants Technology Department, November 1995.
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KEYWORDS: Pollution, Emission, Sulfur-tolerant, JP-8, ULSD, Fischer-Tropsch

A06-238 TITLE: <u>Remote Autonomous Robot Mounted Laser Night Vision Surveillance System</u>

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Research and design a modular, mountable eye-safe laser night vision system capable of broadcasting crystal clear images. The night vision system should provide clear images in night time/zero light, daylight. The laser should be capable of seeing through glass with zero or minimal detectable signature.

DESCRIPTION: Soldiers are high risk target when patrolling vehicle checkpoints, US/foreign boarders and parameter surveillance. A mountable 360 degree field of view laser night vision system will remove the need to put the soldier in harms way.

Current night vision systems in the field use ambient light and are subject to blinding by incandescent light and thermal radiation. This research is to investigate and develop a system whereby high power lasers could potentially be used with reflective technology to provide 360 degree illumination. We are looking for approaches that could penetrate glass, including security, smoked and colored windows. This technology could allow operators to use their equipment from within a protected vehicle.

The concept for laser based illumination is to use low power consumption over LED and Halogen products with improved clarity and an illumination distance from 300 feet to 3,000 feet. The display would show the current field-of-view that could be integrated with WiFi technology, yielding infinite signal options. Part of the research is determining user intent and modification limits for various size, weight and power demands.

The purpose of improved clarity could enable greater sensory perception and situational awareness, potentially demonstrated with MRI brain activity imagery. Research may include the addition/value of holographic imagery. Processes should include Critical to Quality (CTQ) analysis for night vision systems with a Six Sigma & Spider Chart approach to optimizing night vision for maximum deployment.

The concept for remote operability is for the user to view over, around and through obstructions, minimizing the threat of exposure to the operator. The research would include investigation of a user tunable frequency control and zoom capabilities. Further investigation is necessary of material and software tamper resistance systems and reverse engineering protection.

The system needs to be reasonably rugged, run in real-time, be compact and standardized enough to be placed on existing platforms. The research should include an investigation into patented technology of eye safe laser development.

PHASE I: The first phase consists of development of superior system design, investigating eye safety concerns, processing techniques, control mechanisms and showing feasibility of size, weight and power capabilities on sample data. Documentation of design tradeoffs, expected performance and feasibility analysis shall be required in the final report. Ideally, designs of various prototype technologies could be produced and preliminary component and system testing data supplies.

PHASE II: The second phase consists of a final design and full implementation of the most effective systems. At the end of the contract, the prototype system shall be integrated with a manned or unmanned vehicle, in accordance with eye safety regulations and successful operation shall be demonstrated at the National Guard Headquarters facility. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in this project and eye safety confirmation.

PHASE III: Commercial applications may include surveillance applications, such as security and inspection, border monitoring, and covert urban and rural exploration.

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KEYWORDS: Sensors, lasers, robotics, night vision, surveillance