ARMY
SBIR 10.2 PROPOSAL SUBMISSION INSTRUCTIONS

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

Solicitation, topic, and general questions regarding the SBIR Program should be addressed according to the DoD portion of this solicitation. For technical questions about the topic during the pre-Solicitation period, contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period, visit http://www.dodsbir.net/sitis. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8:00 am to 5:00 pm ET). Specific questions pertaining to the Army SBIR Program should be submitted to:

John Pucci
Program Manager, Army SBIR (Acting)
army.sbir@us.army.mil

US Army Research, Development, and Engineering Command (RDECOM)
ATTN: AMSRD-PPB
6000 - 6th Street, Suite 100
Fort Belvoir, VA 22060-5608
(703) 806-2085
FAX: (703) 806-0675

The Army participates in three DoD SBIR Solicitations 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.

SUBMISSION OF ARMY SBIR PROPOSALS

Army Phase I Proposals have a 20-page limit which includes the Proposal Cover Sheets (pages 1 and 2) and Technical Proposal (which begins on page 3 and may include: table of contents, pages left blank intentionally by you, references, letters of support, appendices, and all attachments). Therefore, a Technical Proposal of up to 18 pages in length counts towards the overall 20-page limit. ONLY the Cost Proposal and the Company Commercialization Report are excluded from the 20-pages. Army Phase I Proposals submitted over 20-pages will be deemed NON-COMPLIANT and will not be evaluated. This statement takes precedence over section 3.4 of the general DoD solicitation instructions. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 20-page limit.

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). When submitting the mandatory Cost Proposal, the Army prefers that small businesses complete the Cost Proposal form on the DoD Submission site, versus submitting within the body of the uploaded proposal. The Army WILL NOT accept any proposals which are not submitted via this site. Do not send a hardcopy of the proposal. Hand or electronic signature on the proposal is also NOT required. If the proposal is selected for award, the DoD Component program will contact you for signatures. If you experience problems uploading a proposal, call the DoD Help Desk 1-866-724-7457 (8:00 am to 5:00 pm ET). 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, they must be clearly identified. **For foreign nationals, you must provide technical resumes, country of origin and an explanation of the individual's involvement. Please ensure no Privacy Act information is included in this submittal.**

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

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

Every Phase I proposal will be reviewed for overall merit based upon the criteria in section 4.2 of this solicitation.

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

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

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

Phase I Key Dates

10.2 Solicitation Pre-release	April 21 – May 18, 2010
10.2 Solicitation Opens	May 19, 2010 – June 23, 2010
10.2 Solicitation Closes	June 23, 2010; 6:00 a.m. ET
Phase I Evaluations	June – August 2010
Phase I Selections	September 2010
Phase I Awards	October 2010*

**Subject to the Congressional Budget process*

PHASE II PROPOSAL SUBMISSION

Army Phase II Proposals have a 40-page limit which includes the Proposal Cover Sheets (pages 1 and 2) and Technical Proposal (which begins on page 3 and may include: table of contents, pages left blank intentionally by you, references, letters of support, appendices, and all attachments). Therefore, a Technical Proposal of up to 38 pages in length counts towards the overall 40-page limit. ONLY the Cost Proposal and the Company Commercialization Report are excluded from the 40-pages. Army Phase II Proposals submitted over 40-pages will be deemed NON-COMPLIANT and will not be evaluated. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 40-page limit.

Note! Phase II Proposal Submission is by Army Invitation only.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and are successfully executing their Phase I efforts, will be invited to submit a Phase II proposal. Generally, invitations to submit Phase II proposals will not be earlier than the 5th month of the Phase I effort. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation.

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

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

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

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

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

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

- The Office of the Assistant Secretary of the Army (Manpower & Reserve Affairs) operates and maintains the secure CMRA System. The CMRA Web site is located here: https://cmra.army.mil/.

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

  (1) Contract number, including task and delivery order number;
  (2) Contractor name, address, phone number, e-mail address, identity of contractor employee entering data;
  (3) Estimated direct labor hours (including sub-contractors);
  (4) Estimated direct labor dollars paid this reporting period (including sub-contractors);
  (5) Predominant Federal Service Code (FSC) reflecting services provided by contractor (and separate predominant FSC for each sub-contractor if different);
  (6) Organizational title associated with the Unit Identification Code (UIC) for the Army Requiring Activity (The Army Requiring Activity is responsible for providing the contractor with its UIC for the purposes of reporting this information);
  (7) Locations where contractor and sub-contractors perform the work (specified by zip code in the United States and nearest city, country, when in an overseas location, using standardized nomenclature provided on Web site);

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

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

Given the small size of our SBIR contracts and companies, it is our opinion that the modification of contractor payroll systems for automatic XML data transfer is not in the best interest of the Government.

CMRA is an annual reporting requirement that can be achieved through multiple means to include manual entry, MS Excel spreadsheet development, or use of the free Government XML converter tool. The annual reporting should take less than a few hours annually by an administrative level employee. Depending on labor rates, we would expect the total annual cost for SBIR companies to not exceed $500.00 annually, or to be included in overhead rates.

DISCRETIONARY TECHNICAL ASSISTANCE

In accordance with section 9(q) of the Small Business Act (15 U.S.C. 638(q)), the Army will provide technical assistance services to small businesses engaged in SBIR projects through a network of scientists and engineers engaged in a wide range of technologies. The objective of this effort is to increase Army SBIR technology transition and commercialization success thereby accelerating the fielding of capabilities to Soldiers and to benefit the nation through stimulated technological innovation, improved manufacturing capability, and increased competition, productivity, and economic growth.

The Army has stationed Technical Assistance Advocates (TAAs) in five regions across the Army to provide technical assistance to small businesses that have Phase I and Phase II projects with the participating organizations within their regions.

For more information go to: http://www.armysbir.com/sbir/taa_desc.htm.

COMMERCIALIZATION PILOT PROGRAM (CPP)

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

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

NON-PROPRIETARY SUMMARY REPORTS

All award winners must submit a non-proprietary summary report at the end of their Phase I project and any subsequent Phase II project. The summary report is unclassified, non-sensitive, and non-proprietary and should include:

- A summation of Phase I results
- A description of the technology being developed
- The anticipated DoD and/or non-DoD customer

- The plan to transition the SBIR developed technology to the customer
- The anticipated applications/benefits for government and/or private sector use
- An image depicting the developed technology

The non-proprietary summary report should not exceed 700 words, and is intended for public viewing on the Army SBIR/STTR Small Business area. This summary report is in addition to the required final technical report and should require minimal work because most of this information is required in the final technical report. The summary report shall be submitted in accordance with the format and instructions posted within the Army SBIR Small Business Portal at http://www.armysbir.com/smallbusinessportal/Firm/Login.aspx and is due within 30 days of the contract end date.

ARMY SUBMISSION OF FINAL TECHNICAL REPORTS

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

ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 10.2 Topic Index

Participating Organizations		PC	Phone
Aviation and Missile RD&E Center (Aviation)		**PJ Jackson**	**(757) 878-5400**
A10-033	Non-Metallic/Metallic Debris Sensor		
A10-034	Unmanned Aerial Vehicle (UAV) Engine Innovative and Durable Sealing Techniques for Increased Power and Efficiency		
A10-035	Fatigue Resistant Martensitic Steel for Rotorcraft Drive Train Components		
A10-036	Miniature Flash LIDAR for Helicopter UAV Obstacle Field Navigation and Landing Site Selection in Complex Urban Environments		
A10-037	Active Terahertz Imager for Covert Navigation Assist		
A10-038	Integrating Fibre Channel and EIA-422 for Weapon System Communications		
Armaments RD&E Center (ARDEC)		**Carol L'Hommedieu**	**(973) 724-4029**
A10-039	Modular Targeting, Prosecution and Effects Delivery Payloads for Small Unmanned Air Vehicles		
A10-040	Closed-Loop Fire Control (CLFC) for Small Caliber Weapons		
A10-041	Novel Multifunctional Lightweight Nanocomposites		
A10-042	Cross-compatible cartridge case for orthodox or rarefaction wave gun firing		
A10-043	Innovative Polarized Navigation Reference		
A10-044	Innovative Nitrogen-doped Boron Nanotubes/Nanofibers Propellants		
A10-045	Novel Directed Energy Propagation Methods for Extended Range Operation		
A10-046	High Rate High Energy Storage Devices		
A10-047	Propulsion System for Confined Space Projectile Launchers		
A10-048	Multi-shot EOD Disrupter for Robotic Applications		
A10-049	Reactive Materials with Reduced ESD Sensitivity		
A10-050	Application of Nanothermite based Modified Composition as Propellant Initiator		
A10-051	Novel Combustible Polymer Cased Small Arms Ammunitions		
A10-052	Innovative Heavy-lifting Manipulators for EOD Robots		
A10-053	Nanostructured Magnesium Composites for Lightweight, Structural Applications		
A10-054	Innovative Non-conventional Imaging Technology for Situational Awareness		

A10-055	A large field-of-view and high resolution camera in a small form factor
A10-056	Affordable GPS-independent Precision Munitions

Army Research Laboratory **Mary Cantrill** **(301) 394-3492**

A10-057	Dynamic Conditioning of Projectiles for Ultra-Lightweight Armor Applications
A10-058	Development of a Two Color Polarimetric Forward Looking Infrared (FLIR) Camera System
A10-059	E-Field Warhead & Projectile Technology
A10-060	Fabrication of High-Strength, Lightweight Metals for Armor and Structural Applications
A10-061	Formation of large single crystals of aluminum oxynitride (AlON) ceramic
A10-062	Inexpensive Large Scale Manufacturing of High Specific Modulus and Strength Ceramic Fibers
A10-063	Cast Encapsulation of Unfinished Ceramic Armor Tiles
A10-064	Light Weight Electric and Magnetic-Field Sensors for Unmanned Aerial Vehicles
A10-065	Probabilistic Forecasting for Aviation Decision Aid Applications
A10-066	Neurological Simulator for Applied Data Collection
A10-067	Programmable Multichannel RF Filter-Equalizer
A10-068	Low Cost Carbon Fluoride Materials for Lithium Batteries
A10-069	Compact, Rugged and Ultrafast Femtosecond Laser for Hazardous Material Detection at Range
A10-070	Compact Light Weight Sulfur Sensor for JP-8 Fuel
A10-071	Profile Feature Extractor (PFx) Sensor Component for Persistent ISR Applications
A10-072	Soldier Adaptability/Human Dimension: Knowledge Management Framework for Network Centric Operations

Army Research Office **Roger Cannon** **(919) 549-4278**

A10-073	Multisensory Navigation and Communications System
A10-074	Universal Bio-Sample Preparation Module
A10-075	Widely-Tunable Distributed-feedback Mid-Infrared Laser for Standoff Chemical Detection
A10-076	Terahertz Emitter Based on Frequency Mixing in Microchip Solid-State Laser Cavity
A10-077	Energy-Dense Hydrocarbons from Eukaryotic Microorganisms

U.S. Army Test & Evaluation Command **Nancy Weinbrenner** **(410) 278-5688**
Michael Orlowicz **(410) 278-1494**

A10-078	Compact, High Intensity, Low Cost, Free Standing Illumination Sources
A10-079	Smart Body Armor Active Protection System
A10-080	Formulation and Production of Novel Barrier Materials

Communication Electronics Command **Suzanne Weeks** **(732) 427-3275**

A10-081	Novel Passive Low Light Level Solid State Imager Development
A10-082	Active Closed Loop Infrared Countermeasures (CLIRCM) Sensor for Rotary Wing Aircraft
A10-083	Multi-Threat Passive Detection for Aircraft Survivability Equipment (MTD-ASE)
A10-084	Wall Characteristic Extraction for Through Wall Radar Systems
A10-085	Scenario Based Modeling of Electronic Systems
A10-086	Spectroscopic Home Made Explosive Detector
A10-087	Identification Based on Individual Scent (IBIS)
A10-088	Forensic Facial Image Analysis providing 3D Mapping, Metatagging, Comparative Operation and Search System
A10-089	Tactical Counter Concealment Aerial Sensors Electronic Protection (TC-CAS EP)
A10-090	Visualization Tools for Causal Data Mining
A10-091	Adversarial Reasoning for Combined Unmanned Aerial Systems (UASs) and Unmanned Ground Vehicles (UGVs)
A10-092	Contextual Framework for Command and Control Decision Making
A10-093	Intelligent Human Motion Detection Sensor
A10-094	Advanced Thermoelectric Milli-Power Source
A10-095	Consistent Visualization Across Battle Command Systems
A10-096	Use of Nanotechnology to Enhance Power and Energy System Performance
A10-097	Enhanced Field Expedient Body Wearable Antenna
A10-098	Adapterless Information Consolidation

A10-099	Solid Hydrogen Fuel Cartridges		
A10-100	Standoff-Biometric for Non-Cooperative Moving Subjects		
A10-101	Repeatable Virtualization of Intelligence, Surveillance & Reconnaissance (ISR) System Servers		
A10-102	Low Cost High Assurance Separation Kernel		
A10-103	Integrated Counter-Mine/Improvised Explosive Device (IED) and Command and Control (C2) Capabilities		
A10-104	Human Signature Collection and Exploitation via Stand-Off Non-Cooperative Sensing		
A10-105	Heuristic-based Prognostic and Diagnostic Methods to Enhance Intelligent Power Management for Tactical Electric Power Generator Sets		
Engineer Research & Development Center		**Theresa Salls**	**(603) 646-4591**
A10-106	Modeling of concrete failure under blast and fragment loading		
A10-107	Development of a user model and information system for multi-tiered approaches for modeling and predicting attributes of engineered nanomaterials		
A10-108	Developing Capabilities for the Visualization and Analysis of Qualitative Data within Geographic Information Systems		
A10-109	Sustainable Materials to Reduce Heat Signatures of Base Camps		
A10-110	Development of a desktop application to integrate tools and databases for environmentally-important chemical aspects of military compounds		
A10-111	Non-rotating Wind Energy Generation		
A10-112	Multiple Mode Structural Health Monitoring System for Equipment and Facilities		
JPEO Chemical and Biological Defense		**Larry Pollack**	**(703) 767-3307**
A10-113	Electronic Sensing Fiber Scaffold Sensor		
A10-114	Monolithic tunable diode laser absorption spectrometer		
Medical Research and Materiel Command		**JR Myers** **Dawn Rosarius**	**(301) 619-7377** **(301) 619-3354**
A10-115	Manufacturing Development of Biomimetic Tissue Engineering Scaffolds		
A10-116	Miniaturized Fluidic Chip for Impedance Monitoring of Vertebrate Cells		
A10-117	Manufacturing Development of Allogeneic Stem Cells in Clinical Settings		
A10-118	Differentiation of Leishmania in the Sand Fly Vector		
A10-119	Ultrafast Fiber Lasers Smart Surgical Tool Development		
Program Executive Office Ammunition		**Vince Matrisciano**	**(973) 724-2765**
A10-120	Laser Vibrometry Detection of SBIEDs		
A10-121	DIm and Imperceptible Tracer Ammunition Product Development		
Program Executive Office Aviation		**Dave Weller**	**(256) 313-4975**
A10-122	Lightweight EMI Resistant Wiring Solutions		
Program Executive Office Combat Support & Combat Service Support		**Robert LaPolice**	**(586) 909-9945**
A10-123	Ultrastrong Dual Use Nanocomposite Materials for Blast and Transparent Armor		
Program Executive Office Ground Combat Systems		**Jim Muldoon** **Peter Haniak**	**(586) 770-3513** **(586) 574-8671**
A10-124	Lithium Ion Batteries with Wide Operating Temperature Range		
A10-125	Plug & Play Integrated Hybrid Power System for Humanoid Robot		
Program Executive Office Integration		**Fran Rush** **Philip Hudner**	**(703) 676-0124** **(703) 676-0082**
A10-126	Reduction of vehicle display-induced motion sickness		

Program Executive Office Missiles and Space		**George Burruss** **Carol Tucker**	**(256) 313-3523** **(256) 876-5372**
A10-127	Advanced Materials and Manufacturing for Lightweight, Low Cost Seeker Gimbals		
A10-128	Missile Based Deployment System		
Program Executive Office Soldier		**John Houston** **TJ Junor**	**(703) 704-3309** **(703) 704-2856**
A10-129	MTBI Protective Mandibular Appliance		
Space and Missiles Defense Command		**Denise Jones**	**(256) 955-0580**
A10-130	USB Firewall for Direct Connect USB Cyber Warfare Protection		
A10-131	Compact Efficient Electrically Small Broadband Antennas		
Tank Automotive RD&E Center		**Jim Mainero**	**(586) 282-8646**
A10-132	High Temperature Silicon Carbide (SiC) Gate Driver		
A10-133	Power regenerative suspension systems		
A10-134	JP-8 Hydraulic Power System for Legged Robot		
A10-135	High Mobility Robotic Platform with Active Articulated Suspension		
A10-136	Scalable technology for military and humanitarian water purification applications		
A10-137	Real Time Thermal Mapping Techniques for Elastomeric Track Components		
A10-138	Development of Super-Capacitor with Improved Energy Density		
A10-139	Lithium Air Rechargeable Battery		
A10-140	Rapidly Deployable Thin Film Camouflage		
A10-141	Acoustic Signature Self Monitoring System		
A10-142	Hands-Free and Heads-Up Control of Unmanned Ground Vehicles		
A10-143	Perception for Persistent Surveillance with Unmanned Ground Vehicles		
A10-144	Urban Time-to-Detect Simulator for Vehicle-Developers		
A10-145	Reduce Thermal/Signature Analysis Cycle Times		

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

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

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

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

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

____ 4. **Army Phase I Proposals have a 20-page limit which includes the Proposal Cover Sheets (pages 1 and 2) and Technical Proposal (which begins on page 3 and may include: table of contents, pages left blank intentionally by you, references, letters of support, appendices, and all attachments). Therefore, the Technical Proposal up to 18 pages in length counts towards the overall 20-page limit. ONLY the Cost Proposal and the Company Commercialization Report are excluded from the 20-pages. Army Phase I Proposals submitted over 20-pages will be deemed NON-COMPLIANT and will not be evaluated. This statement takes precedence over section 3.4 of the general DoD solicitation instructions. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 20-page limit.**

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

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

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

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

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

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

Army SBIR 10.2 Topic Index

A10-033 Non-Metallic/Metallic Debris Sensor
A10-034 Unmanned Aerial Vehicle (UAV) Engine Innovative and Durable Sealing Techniques for Increased Power and Efficiency
A10-035 Fatigue Resistant Martensitic Steel for Rotorcraft Drive Train Components
A10-036 Miniature Flash LIDAR for Helicopter UAV Obstacle Field Navigation and Landing Site Selection in Complex Urban Environments
A10-037 Active Terahertz Imager for Covert Navigation Assist
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A10-046 High Rate High Energy Storage Devices
A10-047 Propulsion System for Confined Space Projectile Launchers
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A10-049 Reactive Materials with Reduced ESD Sensitivity
A10-050 Application of Nanothermite based Modified Composition as Propellant Initiator
A10-051 Novel Combustible Polymer Cased Small Arms Ammunitions
A10-052 Innovative Heavy-lifting Manipulators for EOD Robots
A10-053 Nanostructured Magnesium Composites for Lightweight, Structural Applications
A10-054 Innovative Non-conventional Imaging Technology for Situational Awareness
A10-055 A large field-of-view and high resolution camera in a small form factor
A10-056 Affordable GPS-independent Precision Munitions
A10-057 Dynamic Conditioning of Projectiles for Ultra-Lightweight Armor Applications
A10-058 Development of a Two Color Polarimetric Forward Looking Infrared (FLIR) Camera System
A10-059 E-Field Warhead & Projectile Technology
A10-060 Fabrication of High-Strength, Lightweight Metals for Armor and Structural Applications
A10-061 Formation of large single crystals of aluminum oxynitride (AlON) ceramic
A10-062 Inexpensive Large Scale Manufacturing of High Specific Modulus and Strength Ceramic Fibers
A10-063 Cast Encapsulation of Unfinished Ceramic Armor Tiles
A10-064 Light Weight Electric and Magnetic-Field Sensors for Unmanned Aerial Vehicles
A10-065 Probabilistic Forecasting for Aviation Decision Aid Applications
A10-066 Neurological Simulator for Applied Data Collection
A10-067 Programmable Multichannel RF Filter-Equalizer
A10-068 Low Cost Carbon Fluoride Materials for Lithium Batteries
A10-069 Compact, Rugged and Ultrafast Femtosecond Laser for Hazardous Material Detection at Range
A10-070 Compact Light Weight Sulfur Sensor for JP-8 Fuel
A10-071 Profile Feature Extractor (PFx) Sensor Component for Persistent ISR Applications
A10-072 Soldier Adaptability/Human Dimension: Knowledge Management Framework for Network Centric Operations
A10-073 Multisensory Navigation and Communications System
A10-074 Universal Bio-Sample Preparation Module
A10-075 Widely-Tunable Distributed-feedback Mid-Infrared Laser for Standoff Chemical Detection
A10-076 Terahertz Emitter Based on Frequency Mixing in Microchip Solid-State Laser Cavity
A10-077 Energy-Dense Hydrocarbons from Eukaryotic Microorganisms
A10-078 Compact, High Intensity, Low Cost, Free Standing Illumination Sources
A10-079 Smart Body Armor Active Protection System
A10-080 Formulation and Production of Novel Barrier Materials
A10-081 Novel Passive Low Light Level Solid State Imager Development

A10-082	Active Closed Loop Infrared Countermeasures (CLIRCM) Sensor for Rotary Wing Aircraft
A10-083	Multi-Threat Passive Detection for Aircraft Survivability Equipment (MTD-ASE)
A10-084	Wall Characteristic Extraction for Through Wall Radar Systems
A10-085	Scenario Based Modeling of Electronic Systems
A10-086	Spectroscopic Home Made Explosive Detector
A10-087	Identification Based on Individual Scent (IBIS)
A10-088	Forensic Facial Image Analysis providing 3D Mapping, Metatagging, Comparative Operation and Search System
A10-089	Tactical Counter Concealment Aerial Sensors Electronic Protection (TC-CAS EP)
A10-090	Visualization Tools for Causal Data Mining
A10-091	Adversarial Reasoning for Combined Unmanned Aerial Systems (UASs) and Unmanned Ground Vehicles (UGVs)
A10-092	Contextual Framework for Command and Control Decision Making
A10-093	Intelligent Human Motion Detection Sensor
A10-094	Advanced Thermoelectric Milli-Power Source
A10-095	Consistent Visualization Across Battle Command Systems
A10-096	Use of Nanotechnology to Enhance Power and Energy System Performance
A10-097	Enhanced Field Expedient Body Wearable Antenna
A10-098	Adapterless Information Consolidation
A10-099	Solid Hydrogen Fuel Cartridges
A10-100	Standoff-Biometric for Non-Cooperative Moving Subjects
A10-101	Repeatable Virtualization of Intelligence, Surveillance & Reconnaissance (ISR) System Servers
A10-102	Low Cost High Assurance Separation Kernel
A10-103	Integrated Counter-Mine/Improvised Explosive Device (IED) and Command and Control (C2) Capabilities
A10-104	Human Signature Collection and Exploitation via Stand-Off Non-Cooperative Sensing
A10-105	Heuristic-based Prognostic and Diagnostic Methods to Enhance Intelligent Power Management for Tactical Electric Power Generator Sets
A10-106	Modeling of concrete failure under blast and fragment loading
A10-107	Development of a user model and information system for multi-tiered approaches for modeling and predicting attributes of engineered nanomaterials
A10-108	Developing Capabilities for the Visualization and Analysis of Qualitative Data within Geographic Information Systems
A10-109	Sustainable Materials to Reduce Heat Signatures of Base Camps
A10-110	Development of a desktop application to integrate tools and databases for environmentally-important chemical aspects of military compounds
A10-111	Non-rotating Wind Energy Generation
A10-112	Multiple Mode Structural Health Monitoring System for Equipment and Facilities
A10-113	Electronic Sensing Fiber Scaffold Sensor
A10-114	Monolithic tunable diode laser absorption spectrometer
A10-115	Manufacturing Development of Biomimetic Tissue Engineering Scaffolds
A10-116	Miniaturized Fluidic Chip for Impedance Monitoring of Vertebrate Cells
A10-117	Manufacturing Development of Allogeneic Stem Cells in Clinical Settings
A10-118	Differentiation of Leishmania in the Sand fly Vector
A10-119	Ultrafast Fiber Lasers Smart Surgical Tool Development
A10-120	Laser Vibrometry Detection of SBIEDs
A10-121	DIm and Imperceptible Tracer Ammunition Product Development
A10-122	Lightweight EMI Resistant Wiring Solutions
A10-123	Ultrastrong Dual Use Nanocomposite Materials for Blast and Transparent Armor
A10-124	Lithium Ion Batteries with Wide Operating Temperature Range
A10-125	Plug & Play Integrated Hybrid Power System for Humanoid Robot
A10-126	Reduction of vehicle display-induced motion sickness
A10-127	Advanced Materials and Manufacturing for Lightweight, Low Cost Seeker Gimbals
A10-128	Missile Based Deployment System
A10-129	MTBI Protective Mandibular Appliance
A10-130	USB Firewall for Direct Connect USB Cyber Warfare Protection

A10-131	Compact Efficient Electrically Small Broadband Antennas
A10-132	High Temperature Silicon Carbide (SiC) Gate Driver
A10-133	Power regenerative suspension systems
A10-134	JP-8 Hydraulic Power System for Legged Robot
A10-135	High Mobility Robotic Platform with Active Articulated Suspension
A10-136	Scalable technology for military and humanitarian water purification applications
A10-137	Real Time Thermal Mapping Techniques for Elastomeric Track Components
A10-138	Development of Super-Capacitor with Improved Energy Density
A10-139	Lithium Air Rechargeable Battery
A10-140	Rapidly Deployable Thin Film Camouflage
A10-141	Acoustic Signature Self Monitoring System
A10-142	Hands-Free and Heads-Up Control of Unmanned Ground Vehicles
A10-143	Perception for Persistent Surveillance with Unmanned Ground Vehicles
A10-144	Urban Time-to-Detect Simulator for Vehicle-Developers
A10-145	Reduce Thermal/Signature Analysis Cycle Times

A10-033 TITLE: Non-Metallic/Metallic Debris Sensor

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, 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: Develop a non-metallic/metallic oil debris monitoring sensor for use on rotorcraft transmissions and turboshaft engines.

DESCRIPTION: The use of hybrid ceramic bearings has significant benefits for use in rotorcraft transmissions and turboshaft engines. The hybrid ceramic bearings have silicon nitride rolling elements with metallic races. These bearings offer the advantage of longer life, less weight, and improved safety over steel bearings in certain applications. To utilize hybrid ceramic bearings in rotorcraft, it is desired to have a sensor capable of detecting debris from both the ceramic elements and the metallic races. Detection of bearing debris and characterization of the debris provides indication of bearing health and supports the Army's goal to transition to condition-based maintenance (CBM). Commercially available oil debris sensors can detect metallic debris (ferrous and non-ferrous) but cannot accurately detect non-metallic debris. Therefore, development and commercialization of a reliable oil debris monitoring system for both non-metallic and metallic debris is necessary to support the Army's CBM objective for hybrid-ceramic bearings.

Desired characteristics of the oil debris sensor are as follows. The sensor should be able to detect non-metallic and metallic (ferrous and non-ferrous) debris. It should be able to distinguish between debris and air bubbles in the oil. The system must characterize the debris, particle sizes, total mass of debris, record the sensor data, and provide data output to the aircraft's health and usage monitoring system (HUMS) via RS232, ARINC 429 or CAN BUS. The sensor shall be capable of handling oil temperatures to 350 degrees F. Electronics shall have an operating range of -40 to 185 degrees F. Objective system weight is 1.5 pounds. The sensor shall also provide algorithms to assess the health of bearings based on the oil debris data.

Other desired attributes to consider for phase III are (1) impact per Mil-Std 810F, Method 516.5; (2) vibration requirements of Mil-Std 810F, Method 514.5; (3) acceleration per Mil-Std 810F, Method 513.5; (4) altitude per Mil-Std 810F, Method 500.4; (5) rain per Mil-Std 810F, Method 506.4; (6) fungus per Mil-Std 810F, Method 508.5; (7) humidity per Mil-Std 810F, Method 507.4; (8) salt spray/fog per Mil-Std 810F, Method 509.4; (9) sand/dust per Mil-Std 810F, Method 510.4; (10) fluid susceptibility per Mil-Std 810F, Method 504; and (11) electromagnetic interference (EMI) per Mil-Std 461E as modified by ADS-37A-PRF Table 1.

PHASE I: Develop and conduct a feasibility demonstration of the proposed oil debris sensor system technology on a laboratory scale. The overall system must be able to produce accurate detection of debris using a bench top setup and include algorithms to characterize the debris, particle sizes, and total mass of debris. This phase should demonstrate key technologies for the sensor concept.

PHASE II: Further design and develop the proposed oil debris monitoring system, preferably coordinating with an airframe or turboshaft engine manufacturer, to fully validate the operating characteristics and performance in a relevant demonstration environment (full-scale components in a rig test). The design and demonstration should provide interfaces to an aircraft HUMS for download of the data and user interfaces for data and diagnostic algorithms of bearing health.

PHASE III: Develop final production configuration and qualify to military standards listed in the description. The technology is applicable to both military and commercial rotorcraft transmissions and turboshaft engines. The system will support improved aircraft safety and allow scheduling of oil samples based on indicated need versus time usage, thus reducing maintenance burden. As this technology matures it can be transition to other applications for transmissions and turboshaft engines. Presently within the Army there are both ground and air vehicles using turboshaft engines/transmissions, and many more throughout the DoD force.

REFERENCES:
1. MIL-STD-810F, DOD Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, 1 January 2000.

2. MIL-STD-461E, DOD Interface Standard Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 20 August 1999.

3. ASD-37A-PRF, Electromagnetic Environmental Effects (E3) Performance and Verification Requirements, 28 May 1996.

KEYWORDS: Oil Debris, Monitoring, Condition-Based Maintenance

A10-034 TITLE: Unmanned Aerial Vehicle (UAV) Engine Innovative and Durable Sealing Techniques for Increased Power and Efficiency

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop and/or demonstrate durable, innovative engine combustion area/hot section sealing techniques that will overcome sealing losses associated with loss of power and efficiency relative to any variety of Unmanned Aerial Vehicle (UAV) heavy fuel engines in the 30 to 150 horsepower class to include but not be limited to turbine, rotary, reciprocating, and non-standard (experimental and non-production) types.

DESCRIPTION: It is well known that loss of power and efficiency in internal combustion engines can be a direct result of combustion area (and associated surrounding areas in turbine engines) losses. By minimizing these losses, power and efficiency can be greatly improved. This effort seeks to establish implementation of novel sealing methods/materials to minimize these losses for a candidate engine (30 to 150 horsepower class heavy fuel engine selected by offerer) and derived estimates of improvements to power and efficiency. Dependent upon the engine/engine cycle selected, it is anticipated that this sealing technology would be applicable to combustion pressures in the 8:1 up to 30:1 compression ratio (up to 6:1 pressure ratio for turbine engines) and up to 2500 degree farenheit combustion temperatures. Proposed sealing techniques must also be durable, long life designs which retain good sealing throughout the life of the engine.

Some examples of these losses are as follows:

Reciprocating Engines: Piston ring blowby, piston ring gap losses, valve/valve seat interface leakage. Ring sealing continues to be an area of ever changing technology. Frictional losses both by the pistons and rings as well as crankcase pressure build-up are known power and efficiency robbers.

Rotary Engines: Apex seal leakage and failure, case leakage. Rotary engines Achilles heel are the apex seals. Wear at higher horsepower to weight ratios continues to be a problem and detract from the reliability and longevity of the engines especially in heavy fuel variants required by the military.

Turbine Engines: For small turbine engines, hot section sealing requirements involve improved sealing of the turbine blades with advanced shroud designs (minimize blade-to-shroud clearance while retaining durability) and durable sealing techniques to improve air to oil sealing of hot bearing sumps in order to minimize use of secondary air flow (which produces a loss to the cycle) for sump pressurization.

Experimental and Non-Standard: Apex seals, sealing vanes. There are numerous experimental concept engines in existence that are either variants on the pistonless rotary concept or are totally in a design class all by themselves. Invariably though, they all must compress an air/fuel mixture in a sealed or momentarily sealing combustion area. Any pressure losses in this area due to insufficient sealing adds to efficiency and power losses.

PHASE I: Offerer will investigate methods and materials required for improved combustion area/hot section sealing for a selected engine. Implementation of said concept(s) should be well thought out. Laboratory testing of coupon samples or small scale application is encouraged. Based on analysis and testing, a quantifiable measure of improvement to efficiency and power shall be presented.

PHASE II: Offerer will apply the methods/materials developed in Phase I to a full scale selected engine. Rig testing and data acquisition will be conducted to determine the actual benefits derived from the improved sealing. Offerer will demonstrate the durability/life capability, validity and versatility of the sealing concept/technique and its ability to be utilized on a large scale production basis.

PHASE III: Offerer will make any final adjustments to the product and look towards mass producing, on a small scale basis, the product and applications of the product to a small engine fleet for long term field evaluation. This will serve to finalize the products final form as well as to validate the life and realized benefits of the product.

DUAL USE APPLICATIONS: This technology is applicable to both military and civilian uses as well as commercial aviation markets. The automobile industry could potentially benefit greatly from this technology with the additional derived benefit of lower vehicle emissions.

REFERENCES:
1. Car Craft Magazine-Piston and Ring Technology-by Marlon Davis and various manufacturers (www.carcraft.com/.../piston_ring_technology/index.html)

2. Advances in Piston Ring technology-by Larry Carley-June 1, 2006. (www.underhoodservice.com)

3. Experimental and Analytical Study of Ceramic Coated Tip Shroud Seals for Small Turbine Engines-Jan 1985-USAAVSCOM TR 84-C-19 and NASA TM 86881

4. The Development of a Stratified Charge Rotary Engine Apex Seal Material, February 1991,by G S Revankar-Deere and Co. Document No. 910627

5. The Impact of Oil and Sealing Airflow, Chamber Pressure, Rotor Speed, and Axial Load on the Power Consumption in an Aeroengine Bearing Chamber, Journal of engineering for Gas Turbines and Power-January 2005, Issue 1, 182, By Michael Flouros

KEYWORDS: Combustion area sealing, hot section sealing, apex seals, vane seals, piston and ring technology

A10-035 TITLE: Fatigue Resistant Martensitic Steel for Rotorcraft Drive Train Components

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

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

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: This topic seeks to increase the high cycle bending and contact fatigue strength of case carburized martensitic steels for use in rotorcraft drive system components through the development of manufacturing processes that significantly reduce the ability of base metal inclusions to serve as crack initiation sites.

DESCRIPTION: Improvements in power density (horsepower/lb) of rotorcraft drive trains is critical to increased performance of the total aircraft. The fatigue strength of mechanical elements such as gears, shafts and bearings typically sizes these components. These components are typically manufactured from high strength case carburized martensitic steel. AMS 6265 is a commonly used aerospace gear material with a moden high cleanliness rating. Bending fatigue endurance strength for this alloy in the carburized, quenched and shotpeened condition is typically 175ksi. Contact stress allowables of 275 ksi are also typical of this material. The steels currently in use are typically double vacuum melted (sometimes triple melted) to reduce impurities and forged to enhance the grain structure. To enhance the fatigue strength, shot peening is often applied to critical areas as a final process. Numerous factors affect the fatigue resistance of carburized steel. They include hardness, residual stress, surface finish, microstructure, grain size, globular and network carbides, intergranular oxidation, microcracking, and the presence of retained austenite. Many of these factors interact to influence wear and fatigue performance. It is well known that subsurface crack initiation often occurs at primary non-metallic inclusions in high strength steels. These inclusions promote stress concentration and act as fatigue crack nucleation sites. The specific crack initiation mechanisms depend on the local stress–strain distribution in the material, which in turn depends on various parameters such as geometry (shape and size of the inclusions), mechanical and physical properties (elastic moduli, thermal expansion, and work hardening properties of the inclusion and matrix), interface conditions between the inclusion and matrix, and arrangement of the inclusions. It is well established both experimentally and theoretically that the size of inclusion is a critical factor in influencing fatigue life. This topic seeks to develop innovative processes for minimizing the size of inclusions and optimizing the interfaces and arrangements between the inclusions and the matrix material. Method D of ASTM specification E45-05 is typically used to rate the inclusion content of high grade aerospace steels like AMS 6265. the AMS 6265 specification shows maximum allowable inclusion ratings for four different inclusion types and two different morphologies based upon microscopic observations of mutiple samples taken from a lot of the material. This topic seeks techniques that can achieve a 50% reduction in these allowable inclusion ratings. Potential approaches might involve innovative forging techniques or thermal/mechanical processing of the forged part prior to machining and caburization/hardening.

PHASE I: During the phase I effort, analysis of the technical approach proposed should be conducted in detail. This analysis should include discussions with rotorcraft airframe manufacturers to identify the specific requirements for application of the process to a gear typically used in a rotorcraft transmission. A preliminary analysis of the potential performance improvements and projected cost of the proposed approach should be conducted. Small scale manufacturing trials and material characterization testing may be conducted to establish basic feasibility and guide the effort to be conducted in Phase II.

PHASE II: The results of the Phase I effort shall be further developed to scale-up the proposed approach and optimize the manufacturing methods. Coordination of the specific approach for optimization and scale-up effort with a rotorcraft airframe manufacturer is encouraged. This development work shall be supported by necessary design and modeling effort. Manufacturing trials and material property development of increased complexity shall be conducted to evaluate the performance of the specific approach. Application of the process to a full scale gear shall be conducted. Fatigue testing to establish the potential benefits shall be conducted. Potential target applications shall be identified and plans for technology insertion and product development conducted.

PHASE III: Effort in this phase would involve further collaboration with the helicopter manufacturer regarding design and manufacture of a specific component to which the process could be applied. Additional specimens would be fabricated incorporating any improvement resulting from the Phase II effort. Additional testing necessary further prove the advantages of the process and potentially qualify it for service could be performed.

REFERENCES:
1. Zhang J, Prasannavenkatesan R, McDowell D, Modeling fatigue crack nucleation at primary inclusions in carburized and shot peened martensitic steel. Journal of Engineering Fracture Mechanics, 2008

Woods JL, Daniewicz SR, Nellums R. Increasing the fatigue strength of carburized spur gear teeth by presetting. International Journal of Fatigue 1999

2. Toyoda T, Kanazawa T, Matsumoto K. A study of inclusions causing fatigue cracks in steels for carburized and shot-peened gears. JSAE Rev1990

3. Wise JP, Matlock DK. Bending fatigue of carburized steels: a statistic analysis of process and microstructure. SAE technical publication No.2000-01-0611, SAE, Warrendale, PA; 2000.

4. Wise JP, Matlock DK, Krauss G. Bending fatigue of carburized steels. Heat Treat Progress 2001

5. Almer JD, Cohen JB, Moran B. The effects of residual macrostresses and microstresses on fatigue crack initiation. Matererial Science Enginering A 2000

6. Kunio T, Shimizu M, Yamada K, Sakura K, Yamamoto T. The early stage of fatigue crack growth in martensitic steel. Int J Fracture 1981

7. Trantina GG, Barishpolsky M. Elastic–plastic analysis of small defects-voids and inclusions. Engng Fract Mech 1984

8. Melander A, Ölund P. Detrimental effect of nitride and aluminium oxide inclusions on fatigue life in rotating bending of bearing steels. Material Science Technology 1999

9. Murakami Y, Kodama S, Konuma S. Quantitative evaluation of effects of non-metallic inclusions on fatigue strength of high strength steels. I: Basic fatigue mechanism and evaluation of correlation between the fatigue fracture stress and the size and location of non-metallic inclusions. International Journal of Fatigue 1989

KEYWORDS: Martensitic, Steel, Gears, Carburization, Fracture, Inclusions, Fatigue

A10-036 TITLE: Miniature Flash LIDAR for Helicopter UAV Obstacle Field Navigation and Landing Site Selection in Complex Urban Environments

TECHNOLOGY AREAS: Air Platform, Sensors

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: Design, build, and test an airworthy flash light detection and ranging (LIDAR) suitable for use as the primary sensor in a flight-critical obstacle field navigation system.

DESCRIPTION: An accurate and reliable terrain sensor is a key enabling technology for helicopter UAV operations in complex urban environments. Ongoing Army research in autonomous obstacle field navigation and landing site selection has shown tremendous promise (Refs. 1-4). Unfortunately, the work to-date has had to rely on scanning LIDAR systems adapted from COTS land survey and industrial measurement components. These systems have shown that they are marginally capable of supporting navigation R&D but tend to be large, fragile, and costly. There is hope, however, in the next generation of LIDAR sensors. Specifically, flash LIDAR systems have the potential to provide an improved capability while being significantly smaller, more robust, and lower cost.

This effort will develop a wide field-of-view (FOV) flash LIDAR suitable for a small helicopter UAV performing autonomous maneuvering at low altitude in a complex urban environment. This effort will begin with a study that explores the design and performance trade-offs for flash LIDARS weighing 0.25 lb, 2.5 lb, and 25 lb, targeted for use on micro, small, and full-scale helicopter UAVs.

Following a successful Phase I effort, a flash LIDAR will be developed to demonstrate the efficacy of said device for autonomous guidance and navigation in complex urban environments. The US Army Aeroflightdynamics Directorate (AFDD) helicopter UAV will be made available as a demonstration test bed if desired. This helicopter is equipped with autonomous guidance and navigation algorithms well suited to flash LIDAR output.

The resulting system would target the following sensing capability: 200m range for objects with 15 percent reflectivity, large field-of-view (FOV > 90 deg), high-resolution focal plane array, 5 Hz frame rate, and 10W power consumption. The sensor should be capable of sensing small wires at shallow incidence angles at 30m range. The pulsed laser should be eye-safe. Data output should be provided in the form of a sensor-frame point cloud along with a separate, dedicated hardware timing signal output. The sensor should be configurable in either a free-running or hardware-triggered mode.

Once developed, a low-cost wide FOV flash LIDAR will have numerous dual-use applications beyond autonomous helicopter flight. Currently, scanning LIDARS enjoy wide use in the civilian world in 3D modeling, industrial automation, survey, and more recently and perhaps most importantly, automotive safety. Flash LIDAR will revolutionize the existing market by replacing large, complex devices with small, solid-state, and lower cost devices instead.

PHASE I: Perform and document a trade-off analysis of sensor range, FOV, resolution, frame rate, weight, power, and cost. Identify design points within the study appropriate to micro, small and full-scale helicopter UAVs, i.e., sensor weight equal to approximately 0.25 lb, 2.5 lb, and 25 lb, respectively. Particular attention should be payed to the tradeoff between FOV and sensitivity. Develop a preliminary design based on the needs of a helicopter UAV. Demonstrate a breadboard implementation of the resulting design.

PHASE II: Build a prototype system and demonstrate it in a relevant environment. If desired, the AFDD small helicopter UAV test bed will be provided as Government-furnished equipment. This helicopter is equipped with autonomous guidance and navigation algorithms well suited to flash LIDAR output.

PHASE III: This system could be used in a broad range of UAV and UGV missions requiring autonomous operations in complex urban environments. Manned helicopters operating in the same environment could also benefit from such a sensor to prevent inadvertent flight into terrain. Numerous dual-use applications also exist including 3D modeling, industrial automation, survey, and perhaps most importantly, automotive safety.

REFERENCES:
1) Whalley, Tsenkov, Takahashi, Schulein, Goerzen, Field-Testing of a Helicopter UAV Obstacle Field Navigation and Landing System, Proceedings of the 65th Annual Forum of the American Helicopter Society, Grapevine, TX, May 2009.

Ref. doc uploaded in SITIS 5/19/10.

2) Fabiani, Whalley, Piquereau, Sanfourche, Le Besnerais, Comparison of Terrain Characterization Methods for Autonomous UAVs, Proceedings of the 65th Annual Forum of the American Helicopter Society, Grapevine, TX, May 2009.

Ref. doc uploaded in SITIS 5/19/10.

3) Tsenkov, Howlett, Whalley, Schulein, Takahashi, Rhinehart, and Mettler, A System for 3D Autonomous Rotorcraft Navigation in Urban Environments, Proceedings of the 2008 AIAA Guidance, Navigation and Control Conference, Honolulu, Hawaii, August 2008.

Ref. doc uploaded in SITIS 5/19/10.

4) Whalley, Schulein, Theodore, and Takahashi, Design and Flight Test Results for a Hemispherical LADAR Developed to Support Unmanned Rotorcraft Urban Operations Research, Proceedings of the 64th Annual Forum of the American Helicopter Society, Montreal, Canada, May 2008.

Ref. doc uploaded in SITIS 5/19/10.

KEYWORDS: flash LIDAR, wide field-of-view, UAV, helicopter, sensors

A10-037 TITLE: Active Terahertz Imager for Covert Navigation Assist

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop a prototype active terahertz (>100 GHz) imager that can render objects through brownout conditions up to 100 m away.

DESCRIPTION: Aids for navigating during brownout conditions [1] have generally used either RADAR or LADAR techniques. [2] Active RADAR techniques penetrate brownout well but render coarse images and are detectable by adversaries at great distances. Active LADAR renders much higher resolution images, but laser radiation is strongly scattered by brownout debris and can pose a safety hazard to ground personnel. Although terahertz signature science is still in its infancy, [3] THz imaging techniques may manifest many of the best attributes of both RADAR and LADAR by combining good penetration with good resolution without posing a radiation hazard.[4] Often cited among its many limitations, [5] the fact that THz radiation is naturally absorbed by water vapor in the atmosphere affords the intriguing opportunity to limit its ultimate propagation range. Thus, by choosing the appropriate THz operational frequency, an active THz imager can penetrate brownout to detect nearby objects while remaining undetectably covert at greater distances.

In order to construct an active THz imager, appropriate THz transceiver and imaging technology must be developed. Although a broadband THz source and detector may be considered, preference is for a narrowband, tunable frequency heterodyne transceiver because of its superior signal to noise, spatial resolution, and tunable propagation range. Equally importantly, the technique for rendering an image (e.g. scanning mirror, phased array scanner, staring focal plane array) should be chosen to allow for rapid image refresh (>1 Hz) over a grid with sufficient resolution to image obstacles up to 100 m away. Since this prototype imager will be designed to assist navigation, it is only necessary that the imager face the direction of motion with a field of view comparable to the pilot's.

PHASE I: Design an active THz imager that can penetrate brownout conditions to image objects up to 100 m away. Detailed descriptions of the transceiver and imager design must quantitatively specify how the chosen technology solutions will perform (e.g. spatial resolution vs range, field of view, pixel signal-to-noise, image refresh rate) in realistic brownout navigation scenarios. The ability to chose the propagation range by adjusting the THz operational frequency must be included. From this design, develop a strategy to construct a laboratory-scale technology demonstrator that will allow AMRDEC to assess the performance of this potential navigation aid.

PHASE II: Construct and deliver to AMRDEC a laboratory-scale technology demonstrator of an active THz imager that can penetrate brownout conditions and detect obstacles covertly. The demonstrator must combine a transceiver and a image rendering system with sufficient resolution to image objects in brownout conditions up to 100 m away within a fixed field of view, preferably with an image refresh rate >1 Hz and an adjustable propagation range. Based on the lessons learned during the construction and initial testing of the demonstrator, deliver an improved design for a deployable active THz imager that can penetrate brownout conditions to render an image of objects up to 100 m away while remaining undetectable at an adjustably greater distance.

PHASE III: A navigation aid for pilots in brownout conditions is increasingly important to ongoing military operations not just in southwest Asia but around the world. This project will provide the means for critically assessing the potential of THz imaging against competing solutions. The insight and technology developed will directly support a number of current or planned navigation assistance acquisition programs. In addition, commercial pilots and both commercial and military drivers sometimes face similar brownout navigation challenges, so this project will naturally develop dual-use technology. Finally, a working THz imager will allow fundamental questions about THz signature science be addressed, potentially opening new commercial and military markets for THz techniques or closing inappropriate ones.

REFERENCES:
[1] http://www.vtol.org/vertiflite/brownout.pdf, http://en.wikipedia.org/wiki/Brownout (aviation)

[2] http://www.navysbir.com/n08 2/N082-124.htm, http://www.navysbir.com/n08 2/N082-147.htm

[3] F.C. De Lucia, Proc. SPIE 6373, 637304 (2006); doi:10.1117/12.683848

[4] S.T. Fiorino et al., Proc. SPIE, Vol. 7324, 732410 (2009); doi:10.1117/12.818922

[5] M.J. Rosker and H.B. Wallace, Microwave Symposium 2007, IEEE/MTT-S International, p. 773 (2007). H.J. Liebe, International J. of Infrared and Milimeter Waves, Vol. 10, p. 631 (Springer, 1989).

KEYWORDS: Bronwout, Navigation assist, Terahertz imaging, Covert active RADAR

A10-038 TITLE: Integrating Fibre Channel and EIA-422 for Weapon System Communications

TECHNOLOGY AREAS: Information Systems, Electronics, Weapons

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

OBJECTIVE: Determine the ability of one electronic device to support two different communications-over-power data protocols using the same physical signal lines for application to tube-launched small guided munitions.

DESCRIPTION: Recent combat operations have highlighted the need for small air-launched guided munitions and current 2.75-inch rocket technology is being extended to fill this need. New guided munitions will require a multi-signal digital connection from the launcher to munitions such as that defined in SAE's Interface for Micro Munitions (IMM). The IMM connection specifies Fibre Channel as its data communications protocol and superimposes these data communications on DC power signals. Fibre Channel is a commercial high speed, high cost protocol that has seen only limited use in military tactical applications, but it is able to support high bandwidth capabilities used by some advanced weapons such as high resolution video. Low speed, low cost serial communications such as those based on EIA-422 are much more common in existing weapon systems. New small guided munitions are being viewed as inexpensive alternatives to the HELLFIRE missile system and this argues that these new small munitions use simpler, cheaper serial communications.

The ideal small guided munition launcher would support both protocols: EIA-422-based serial communications for simple, cheap munitions and Fibre Channel communications for more capable, more expensive munitions. However, the two protocols are significantly different. Fibre Channel requires a sophisticated network infrastructure while serial communications are point-to-point with minimal overhead. Fibre Channel communications operate at 1 Ghz while current weapon system serial communications typically operate at much less than 1 Mhz. This frequency difference poses challenges for efficiently extracting both types of digital data from the same analog DC power signal as required by the SAE's IMM.

This topic will explore technologies for simultaneously supporting both Fibre Channel and simple EIA-422-based serial data protocols within the context of the IMM requirement to superimpose data communications over DC power.

PHASE I: Phase I will be a trade study that investigates various existing and theoretical techniques for implementing a dual-protocol Launcher Electronics Assembly (LEA) capable of communicating using either Fibre Channel or an alternative low cost serial protocol. The study should include an analysis of possible options, their advantages and disadvantages and the relative costs and performance with respect to each other. Recommendations for the path to follow in Phase II should also be provided.

PHASE II: Phase II will focus on implementing the recommendations of the Phase I trade study by implementing hardware prototypes of the dual-protocol LEA, Fibre Channel-based munition, and serial-based munition and by conducting a proof of principle demonstration. Phase II deliverables will include the prototype hardware and supporting design documentation.

PHASE III: Phase III would address cost and supportability issues that would make the newly developed commercial, standards-based, dual-protocol technology suitable for incorporation into the Joint Attack Munition Systems (JAMS) new Modernized Rocket Launcher.

REFERENCES:
1. Society of Automotive Engineers. AS5726, Interface Standard, Interface for Micro Munitions. Draft, 5 February 2009.

2. Tian, H., T. Trojak, and C. Jones. Data Communications Over Aircraft Power Lines, AFFTC-PA-05139. Air Force Flight Test Center. June 2005.

3. Tian, H. and C. Jones. Data Communications Over Aircraft Power Lines: A Practical Implementation. http://www.ttcdas.com/products/daus_encoders/pdf/_tech_papers/tp_copl.pdf, accessed 26 October 2009.

4. U.S. Navy LOGIR Program. Dispenser-to-Munition Interface Control Document (ICD) For the Prototype LOGIR Carriage System (PLCS), v. 2.1. 24 October 2007.

5. U.S. Army Joint Attack Munition Systems. MIS-44273U, Interface Control Document, M299 Launcher TO AGM-114 Missiles and AN/AWM-101A Test Equipment. 28 January 2008.

KEYWORDS: Fibre Channel, Rocket, Launchers, Smart Weapon, Weapon Control, Weapon Systems, Guided Missile

A10-039 TITLE: Modular Targeting, Prosecution and Effects Delivery Payloads for Small Unmanned Air Vehicles

TECHNOLOGY AREAS: Air Platform, Information Systems, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Investigate and demonstrate innovative and robust algorithms, architectures and hardware/software implementation approaches for a small unmanned air vehicle compatible targeting, prosecution and effects payload that is modular, interchangeable and re-configurable and that will provide an ability to detect, track, geo-locate, classify and hand-off targets, including dismounted and/or hostile UAV targets, to other small organic UAV platforms and/or small unit targeting/effects assets. Identify emerging protocols, standards, and frameworks that can simplify the interchanging of targeting/effects payload components and reconfiguration of small unmanned air vehicles for multiple platform targeting and prosecution roles and missions including real time fires adjustment, battle damage/collateral damage assessment, and potential re-targeting.

DESCRIPTION: Currently available small, hand-launchable UAVs have limited target geo-location/tracking accuracy and virtually no capability to automatically search, detect/ track dismounted targets or provide any effects delivery capability. Advances in small/micro UAVs, sensors, computing and distributed processing algorithms and architectures and enabling targeting/effects mission package component technologies however, now make feasible a new generation of small/micro UAVs capable of performing a number of target acquisition and effects delivery roles currently only performed by manned platforms and/or larger UAVs controlled at Brigade or higher echelon. More specifically, these advanced small UAV and sensor/effects/processing payloads will provide the current/future force small combat unit and mounted/dismounted soldier with the capability to rapidly employ small man portable, hand launchable small unmanned air vehicle based targeting sensors and networked scalable target effects to support full spectrum operations in urban and complex terrain. However, due to the limited space, weight, power, processing and endurance capabilities of these small UAV platforms, significant innovation will be required in algorithm, software and computing hardware design approaches, including agent based distributed sensor processing and fusion of targeting information from multiple platforms, to achieve required localization, tracking and terminal guidance performance. In addition, sensor, processing and effects payload components must be highly modular, re-configurable with standards based open interfaces that can be easily retrofitted on commercially available small UAVs that would potentially be deployed at the small unit level. Capability will enable the small unit leader/soldier to rapidly detect, acquire, geo-locate and track high priority personnel/threat targets in defilade and/or concealed positions at tactical and operational distances, in day/night environment, estimate wind direction/speed at target location and rapidly hand-off target data to the small unit effects network to support collaborative target engagement and effects delivery. Innovative, real time high resolution multi-spectral sensor/image processing, stabilization, fusion and tracking techniques will be required which exploit emerging, state-of-the-art low cost, low power, high throughput system-on a chip processor technology and architectures in order to achieve highly automated feature/motion based detection, lock-on, tracking and hand-off of both target image and geo-location data, classification, target location error estimates, wind estimates, damage assessment etc to a small unit effects network via an IP based digital radio link by the dismounted soldier/operator. The architecture and algorithm approach should take into consideration communication bandwidth constraints/latency and allow reuse and sharing of software components by small UAV developers and integrators without requiring the use of the same sensor/effects payload hardware (e.g., EO/IR, data links, laser designators, SAR, etc.).

PHASE I: Investigate innovative algorithms and real time processing architectures with potential to meet the topic requirement. Conduct analysis to determine feasibility of the design concept including overall software/hardware component design approach and accompanying algorithms for optimized target search, detection, geo-location, designation, tracking, hand-off, prosecution and communications link selection. Analysis and concept definition should address algorithm processing requirements, target location estimation accuracy, sensor spectral and resolution requirements, communication requirements, throughput/ bandwidth requirements, conceptual hardware/software architecture and interfaces. Document results

PHASE II: Develop demonstration prototype small Unmanned air vehicle modular, open architecture payload which integrates hw/sw component technologies and algorithms for target detection, geo-location, tracking, designation, hand-off, prosecution, effects delivery/assessment and/or mapping with commercially available small UAV platform in a wireless, net-centric test environment. The component/application package must be capable of follow-on maturation and configuration to enable seamless integration and insertion within the future force/current force experiments. Conduct prototype testing to demonstrate, validate and benchmark prototype performance and document results.

PHASE III: The algorithms, software and prototypes developed under this effort address current force special operations requirements as well as Future Force Ground Soldier and small unit network lethality requirements and 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, port security, airport security, search and rescue and FEMA could use this capability in automating their response to security incidents or natural disasters. This capability can also be used by private security companies which provide large scale industrial security at power plants, chemical plants, etc.

REFERENCES:
1. Ludington, B., Johnson, E., and Vachtsevanos, G., "Augmenting UAV Autonomy: Vision-Based Navigation and Target Tracking for Unmanned Aerial Vehicles," IEEE Robotics and AutomationMagazine, vol. 13, issue. 3, 2006, pp 63-71.

2. Steven Yi, “a Novel multiple target tracking system on UAV platforms.” SPIE International Symposium on Defense and Security 2006.

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

4. Joshua Redding, Timothy W. McLain, Randal W. Beard, Clark Taylor, "Vision-based Target Localization from a Fixed wing Miniature Air Vehicle," American Control Conference, Minneapolis, Minnesota, June 2006,

5. Stroupe, A. W.; Martin, M. C.; and Balch, T. R. 2001. Distributed sensor fusion for object position estimate by multi-robot systems. In ICRA-01, 1092--1098. IEEE Press.

6. Fife, W., Archibald, J., “Reconfigurable On-Board Vision Processing for Small Autonomous Vehicles”, EURASIP Journal on Embedded Systems, vol 2007, article ID 80141, 200

KEYWORDS: real time battle damage assessment, target geo-location, small/micro unmanned air vehicles, network effects, target detection, open architecture, modular payloads

A10-040 TITLE: Closed-Loop Fire Control (CLFC) for Small Caliber Weapons

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

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

OBJECTIVE: Design and develop a closed-loop fire control device for small caliber weapons that utilizes LADAR technology to track a fired projectile and the target and provides an improved aimpoint for the next round fired to ensure target impact.

DESCRIPTION: Small weapons combat lethality requires rapid and accurate aiming adjustments to ensure target elimination. A soldier’s preference is target impact with a single shot, but due to the complexities of the modern battlefield, this single shot impact is not always possible. First round hit probability is influenced by several factors, which include human aiming errors, down range wind, atmospheric conditions (temperature/pressure), variations in target and shooter elevations, target state (moving, accelerating) and variations in muzzle velocity. Currently, when a soldier fires the first round at a target and misses he attempts to adjust his fire to correct for the impact error. However, under the stress of active combat engagement, the human-based correction mechanism to address all of the possible hit probability influences may not always be accurate enough and the adjustment may not lead to target impact.

New advancements in laser RADAR (LADAR) technologies may lead to a pathway to circumvent the human-based aiming correction mechanism. It is envisioned that a LADAR system in conjunction with an adjustable aimpoint display can be used to track the fired projectile and in the case of a target miss, present an improved aimpoint to the shooter to greatly increase the probability of target impact on the next fired round. The proposed closed-loop fire control (CLFC) system will accomplish this feat by measuring how far a round misses a target by, and subsequently providing an adjusted aimpoint to the shooter. The CLFC system will factor in the aforementioned environmental, location, target state and muzzle velocity variables when determining the final firing trajectory to help ensure accurate fire. Thus, by giving the soldier a more precise firing trajectory, the lethality of the soldier can be greatly enhanced.

PHASE I: Identify components and architecture for tracking small caliber projectiles and calculating an improved aimpoint for subsequent firing. A trade-off study shall be preformed to determine best components for laboratory-scale device. Identified LADAR system must be eye-safe.

PHASE II: Leverage results from Phase I design effort and develop proof-of-concept breadboard device to demonstrate technologies and capabilities. Upon completion of proof-of-concept device, further develop system to reduce the size, weight and power (SWAP) of the closed-loop fire control system. SWAP developed system shall be mountable on small caliber weapon and shall be able to function in foggy and dusty conditions. Phase II will culminate with delivery of weapon mountable system. Accuracy of system shall be analyzed by evaluating the probability of hit as the performance metric.

PHASE III: Finalize system technology and develop manufacturing capabilities for weapon mountable system. Dual use applications include use for Homeland Security, FBI, and tactical police forces.

REFERENCES:
1. MIL-STD-810G
2. 2009 SPIE Defense Security Symposium, Paper 7325-29

KEYWORDS: LADAR, Fire Control, Weapon Systems, Small Caliber

A10-041 TITLE: <u>Novel Multifunctional Lightweight Nanocomposites</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Exploit emerging nano-materials technologies to develop and optimize nanocomposites to result in multifunctional materials, such as lightweight structural materials with radio frequency-electromagnetic interference (RF/EMI) shielding.

DESCRIPTION: Nanocomposites, the integration of nanomaterials into metals, polymers and ceramics, are an area of intense interest to the Army for the design of next generation lightweight structures with enhanced properties and multifunctional capabilities. Lightweight structural systems can be realized through the development of composites having nanoscale reinforcement with the proper morphological control. Metal matrix composite systems such as aluminum or magnesium reinforced through carbon nanotube and/or other dispersoid inclusion is one area of interest. While the nano reinforcement offers enhanced properties as compared to their traditional counterparts, such composites can be engineered for multifunctionality. For example, the aforementioned metal matrix composite can be designed as a structural component with sufficient RF/EMI shielding for sensitive military applications including but not limited to, components for munitions housings/casings. Thus, the goal of this effort is to demonstrate novel nanocomposites designed preferably through the particulate route, with a high strength to weight ratio and RF/EMI shielding equivalent to or better than currently fielded materials in accordance with MIL-STD-461E and other appropriate standards.

PHASE I: Demonstrate that the impressive properties of nanoscale materials can be imparted to a macro-scale composite. Identify fillers and matrix materials, synthesis and processing technologies/parameters that result in lightweight structural nanocomposite materials suited to replace heavier materials systems that are currently in use. Quantify the effect of nanoscale particulate additives and design on the overall properties of the composite and demonstrate a tensile strength in excess of 600MPa at 5% elongation. Deliver candidate composites to the Army for property validation

PHASE II: (a) Scale up manufacturing processes for producing prototypes of at least 12" x 12" in size. (b) Modify as required (prototype geometry, composition, processing, etc.) and quantify mechanical properties with respect to the areal density of the nanocomposites. (c) Integrate the electromagnetic interference (EMI) shielding capability into the optimized hybrid nanocomposite structures.

PHASE III: Potential dual use applications include structural elements for munitions components, helicopters and aircraft, armored transports for counter-terrorism protection, vehicle protection, and Government buildings.

REFERENCES:
1. R.Siegel, “Mechanical behavior of polymer and ceramic matrix nanocomposites”, Scripta Materialia, Volume 44, Issue 8, (2001) Pages 2061-2064

2. Srinivasa R. Bakshi, Virendra Singh, Kantesh Balani, D. Graham McCartney, Sudipta Seal, Arvind Agarwal, ”Carbon nanotube reinforced aluminum composite coating via cold spraying,”Surface & Coatings Technology 202 (2008) 5162–5169

3. Junichi Yuuki, Hansang Kwon, Akira Kawasaki, Akira Magario, Toru Noguchi, Junichi Beppu, Masayuki Seki “Fabrication of Carbon Nanotube Reinforced Aluminum Composite by Powder Extrusion Process,” Materials Science Forum (Volumes 534 - 536), Progress in Powder Metallurgy Pages 889-892 DOI 10.4028/www.scientific.net/MSF.534-536.889

4. Chan B. Mo, Seung I. Cha, Kyung T. Kim, Kyung H. Lee, Soon H. Hong “Fabrication of carbon nanotube reinforced alumina matrix nanocomposite by sol–gel process” Materials Science and Engineering A 395 (2005) 124–128

5. Katsuyoshi Kondoh, EL-Sayed Ayman Hamada, Hisashi Imai, Junko Umeda, Tyrone Jones, “Microstructures and mechanical responses of powder metallurgy non-combustive magnesium extruded alloy by rapid solidification process in mass production,” Materials and Design 31 (2010) 1540-1546

KEYWORDS: light weight, structural, nanomaterials, composites; hierarchical, multi-functional; shielding

A10-042 TITLE: Cross-compatible cartridge case for orthodox or rarefaction wave gun firing

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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

OBJECTIVE: Research, develop and demonstrate novel methods to incorporate new cartridge case design that will function normally when fired from an orthodox (closed-breech) gun, but will enable blowback venting when fired from a rarefaction wave gun armament.

DESCRIPTION: Rarefaction wave gun (RAVEN) has provided a true breakthrough in armament technology for highly mobile lightweight and lethal combat systems. As is discussed below, it reduces gun barrel heating, erosion, and recoil. It allows lighter guns to fire bigger or faster bullets.

Current and developmental tank guns and counter rocket artillery and mortar systems burn through barrels. Propellant energy is reduced until the minimum acceptable life can be achieved. The subsequent loss of muzzle velocity potential reduces the performance due to time of flight disturbances (accuracy) and stand-off engagement potential. Similarly, area protection lethality is limited by the recoil and weight of armaments.

When fired from a RAVEN, the breech seal of the cartridge case is only maintained until the bullet has traversed some substantial portion of its travel down the bore, e.g., one third. After this, the propellant gases are diverted through or around the case head and into a rearward directed expansion nozzle that generates forward thrust to eliminate all or part of the recoil momentum endowed by the launch. Delayed venting of a cartridge case in this manner is unprecedented and novel technology innovation is essential to achieve the performance of a worthy weapon.

As with many disruptive innovations, there is a strong incentive to achieve a common modular interface between this weapon technology and the ammunition that it is to fire. The logistic burden required to field a new suite of ammunition that would only be compatible with RAVEN firing would be high. A great advantage could be attained if unprecedented ammunition designs could be adapted to function in both current orthodox weapons as well as provide robust performance with the radically different requirements when functioning in new rarefaction wave guns.

The primary challenge when firing this round from a RAVEN is to punch out or rupture the center of the cartridge case head early during the chamber pressure rise following ignition. (This is analogous to the existing 105mm RAVEN demonstrator.) In such a system, the case head is partially supported by a breech block with a center hole that is fixed to the barrel during firing. The unsupported ballistic pressure is applied to a blow-back bolt; driving it rearwards through the center hole and endowing it with velocity. Once ruptured, the case head would still be required to obturate the fixed portion of the breech closure as well as the blow-back bolt as it traverses the vent tube (breech block center hole). No gases should leak prior to the passage of the bolt through the vent passage. This operation results in a swift “uncorking” of the chamber pressure due to the rearward velocity endowed within the bolt. That portion of the cartridge that is punched out and recoils rearward with the bolt must also protect the bolt face from undue heating during the rapid rearward flow of hot propellant gases following venting. This is the primary challenge of this project.

With respect to firing from orthodox (legacy) weapons, such a case must properly function and remain intact and extractable when fired from legacy closed breech cannon. This is a secondary challenge of this project. The rational to integrate cross-compatibility within this project is the self evident opportunity presented by the fact that when fired from a normal closed breech gun, the full support of the case head may be anticipated to reliably prevent vent functioning (case rupture). This innovative approach bypasses one of the most challenging impediments to adoption of disruptive technology. Modular compatibility with existing systems. So, in addition to the complexity and unprecedented nature of the rarefaction wave venting cartridge, the defense department may reap a large logistic benefit with respect to legacy systems when both types are concurrently fielded. Ammo developed to be fired from the new rarefaction wave gun could also be fired from existing cannon without venting gases. One common cartridge could service two radically different weapons.

The focus of the SBIR is on innovative case design and supporting manufacturing knowledge and technology. Proposers at their discretion may opt to include engineering of the vent tube as it relates to obturating the chamber after rupture but prior to venting. Proposers preferring to assume a constant diameter hole through the fixed portion of a breech, are welcome to do so. It is not the intent of the SBIR to engineer a weapon system, projectile, propelling charge, or a munitions handling system.

The final objective caliber of this project is any currently used (or acquisition pending) department of defense large caliber cartridge for bullets of 57mm or greater diameter. Subscale demonstration is acceptable provided a clear technology development path to an objective caliber is included within the project execution plan. Subscale demonstration if chosen must exceed the following minimum ballistic metrics to provide credible traceability to objective caliber: 1) muzzle kinetic energy must be greater than 100 kJ, 2) muzzle velocity must be greater than 1,000 m/s, 3) peak chamber pressure must be greater than 300 MPa, 4) bore diameter must not be less than 25mm, and 5) projectile travel must be greater than 30 calibers. Further, to avoid impractical designs, the peak pressure and projectile travel length shall be less than 700 MPa and 80 calibers respectively.

PHASE I: Investigate innovative methods to design and fabricate a case that will provide robust and reliable service when fired from orthodox guns and rarefaction wave guns. Conduct simulation (computational and/or experimental) of the objective caliber ballistic environment to enable this development and validate the model to the extent practicable. The design must predict the weight and propellant volume of the new cartridge and compare it to the legacy cartridge case. If subscale demonstration is anticipated to be proposed for potential continuation efforts beyond phase I, the feasiblity of fabrication of subscale demonstration cases is also encouraged.

PHASE II: Develop, simulate, and demonstrate a prototype capability in a laboratory environment for the objective caliber. Conduct firing tests of cases (objective caliber or subscale) from closed breech guns to demonstrate successful function (including extraction) in the legacy environment. Although rarefaction wave testing is desired, simplified ballistic tests that fire no bullet, just the blowback bolt may be proposed as a relevant test environment. Conduct simulation (computational and/or experimental) of the objective caliber ballistic and rough handling environment to demonstrate case function to the extent practicable. The weight and propellant volume of the new cartridge must be compared to the legacy cartridge case. Simulation tools must be validated by the firing tests.

PHASE III: The manufacturing technology and cartridge case design fostered by this effort will have dual use applications for both future rarefaction wave guns as well as current legacy guns at objective calibers. This capability may be leveraged to decrease manufacturing cost, increase design robustness, and achieve precision manufacturing and assembly of cartridges to support the warfighter and home land security forces.

REFERENCES:
1. E. Kathe et al, "Rarefaction Wave Gun Tank Main Armament Demonstrator," 26th Army Science Conference, Orlando, FL, 1-4 December 2008. www.asc2008.com/manuscripts/D/DO-01.pdf

2. F. Zhang, "Study of Influence Factors on Launching Performance of Rarefaction Wave Gun," Journal of Ordnance, v29n1, China Ordnance Society, Beijing, China, 2008.

3. W. Yingze et al, "Interior Ballistic Study on Rarefaction Wave Gun Based on Theory of Two-phase Flow," Journal of Ballistics, v19n4, Nanjing University of Technology and Engineering, Nanjing, China, December 2007.

4. T. Coffee, "Modeling of the 35-mm rarefaction wave gun," JANNAF 44th Combustion Subcommittee Meeting, San Diego, CA, December 4-7, 2006.
http://handle.dtic.mil/100.2/ADA451345

5. E. Kathe, "Rarefaction Wave Gun Propulsion," Ph.D. Thesis, Rensselaer Polytechnic Institute, Troy, NY, May 2002. http://handle.dtic.mil/100.2/ADA435128

6. E. Kathe and R. Dillon, "Sonic Rarefaction Wave Low Recoil Gun," AIAA-010743, 39th AIAA Aerosciences Meeting and Exhibit, Reno, NV, January 2001, http://handle.dtic.mil/100.2/ADA398942

7. “The Unperforated Cartridge Case” within Engineering Design Handbook: Recoilless Rifle Weapon Systems, AMCP-706-238, Army Materiel Command, Alexandria, VA, January 1976.—Note—This reference and related chapters provides design guidance that does not have direct applicability to this project, but, may provide useful perspective on some aspects of vent integration within cartridge cases. http://handle.dtic.mil/100.2/ADA023513

8. "Cartridge Case and Gun Chamber Design," within Engineering Design Handbook: Ammunition Series: Section 4: Design For Projection, AMCP-706-247, Army Materiel Command, Alexandria, VA, July 1964.
http://handle.dtic.mil/100.2/AD830296

KEYWORDS: cartridge case, munitions, rarefaction wave gun, auto cannon, materials, manufacturing materials, manufacturing processes, manufacturing accuracy, assembly, fabrication, manufacturing technology, manufacturing engineering, manufacturing knowledge

A10-043 TITLE: Innovative Polarized Navigation Reference

TECHNOLOGY AREAS: Air Platform, 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: The objective of this project is to develop an innovative adaptive polarized RF reference source for establishing a position and orientation referencing system over an entire battlefield. This type of referencing system can be used by polarized RF sensors on guided munitions, ground and airborne platforms, and on the soldier to determine position and orientation relative to the coordinate system. This grid could be used to initialize other position and orientation sensory devices such as inertia-based devices.

DESCRIPTION: Innovative methods to establish position and orientation referencing systems using polarized radio frequency reference sources over an entire battlefield are needed. Such a system will act as a local navigation referencing system similar to the Global Positioning System (GPS) but over the battlefield space. The sources may be fixed or mobile, on the ground or in the air. The establishment of such a 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 independent of the GPS.

This system will significantly reduce errors due to cross-referencing, loss of GPS signal, inherent errors in inertia devices and rate gyros which will greatly improve the effectiveness of munitions guidance and control systems.

This 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. Such a referencing system could be used for command and control, and by forward observers, UAV, and warfighters alike.

The proposed innovative reference sources must be relatively small and low-power, rugged, and should be adaptive, i.e., capable of being deployed very quickly without calibration or adjustments. The proposed referencing system must be capable of providing referencing signals at rates of at least 10 KHz, using methods and protocols that minimize the possibility of detection, spoofing and jamming. This effort must address the amount of power necessary to reject interference from jamming and spoofing as a function of distance to the jamming source. The frequency of operation of the referencing system should be in the range of 8-100 GHz. The proposed solution must not use signals from the Global Positioning System for its operation. The proposed concept must be easy to deploy, must provide a reliable and secure reference source, and must be capable of being synchronized to form a position and orientation referencing system with built-in redundancy, be capable of covering a very large area, portions of which may not be in line-of-sight.

PHASE I: Develop innovative adaptive polarized RF sources 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. Develop analytical models to simulate the performance of the proposed RF sources.

PHASE II: 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 adaptive RF sources for full position and orientation referencing have a wide range of military, homeland security and commercial applications. For military applications, the position and orientation referencing system would enable smart munitions, weapon platforms, vehicles and warfighters to have a common, accurate, reliable and secure position. The referencing system could be used for guidance and control of all smart munitions, missiles and guided bombs, and ground and airborne weapon platforms with minimal error due to the use of a single position and orientation referencing system. Homeland security and commercial applications include guidance and control for robotic systems used in hazardous environments, and materials handling applications involving cranes; loading equipment, and industrial equipment used in assembly, welding, inspection, and other similar operations.

REFERENCES:

1. Illuminated height PDF of a random rough surface and its impact on the forward propagation above oceans at grazing angles, Bourlier, C.; Pinel, N.; Fabbro, V.; Antennas and Propagation, 2006. EuCAP 2006. First European Conference on 6-10 Nov. 2006 Page(s):1 - 6

2. Forward Propagation over Thick Oil Spills on Sea Surfaces for a Coastal Coherent Radar, Pinel, N.; Bourlier, C.; Geoscience and Remote Sensing Symposium, 2008. IGARSS 2008. IEEE International, Volume 4, 7-11 July 2008 Page(s):IV - 1125 - IV - 1128

3. A comparison of forward-boundary-integral and parabolic-wave-equation propagation models, Rino, C.L.; Kruger, V.R.; Antennas and Propagation, IEEE Transactions on Volume 49, Issue 4, April 2001 Page(s):574 - 582

4. A New Combined Measurement Method of the Electromagnetic Propagation Resistivity Logging, Xing, G.; Wang, H.; Ding, Z.; Geoscience and Remote Sensing Letters, IEEE Volume 5, Issue 3, July 2008 Page(s):430 - 432

5. Effects of the variability of atmospheric refractivity on propagation estimates, Rogers, L.T.; Antennas and Propagation, IEEE Transactions on Volume 44, Issue 4, April 1996 Page(s):460 - 465

6. EM propagation in tunnels, Delogne, P.; Antennas and Propagation, IEEE Transactions on Volume 39, Issue 3, March 1991 Page(s):401 - 406

7. Energy transport velocity of electromagnetic propagation in dispersive media, Schulz-DuBois, E.O.; Proceedings of the IEEE, Volume 57, Issue 10, Oct. 1969 Page(s):1748 - 1757

8. Hybrid empirical-neural approach in modeling EM propagation in urban environment with foliage areas, Milovanovic, B.; Milijic, M.; Stankovic, Z.; Neural Network Applications in Electrical Engineering, 2008. NEUREL 2008. 9th Symposium on 25-27 Sept. 2008 Page(s):179 - 182

9. Line-of-sight EM propagation experiment at 10.25 GHz in the tropical ocean evaporation duct, Kulessa, A.S.; Woods, G.S.; Piper, B.; Heron, M.L.; Microwaves, Antennas and Propagation, IEE Proceedings - Volume 145, Issue 1, Feb. 1998 Page(s):65 - 69

10. Coplanar Waveguide Circuits, Components, and Systems, Rainee N. Simons Book;2001; ISBN 0-4711-6121-7; Product No.: PC5948-TBR.

11. A Coplanar Waveguide Bow-Tie Aperture Antenna,G. Zheng, A. Elsherbeni, C. Smith, University of Mississippi, USA.

12. Synthesis of Irregular Waveguide Field Transformation Elements using a Multi-Resolution Algorithm, M.-C. Yang, K. Webb, Purdue University, USA.

13. Modeling of Mode Excitation and Discontinuities in PBG Waveguides, F. Capolino, D. Jackson, D. Wilton, University of Houston, USA.

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

A10-044 TITLE: Innovative Nitrogen-doped Boron Nanotubes/Nanofibers Propellants

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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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, cost-effective nano-additives in high-energy propellant formulations for reducing gun bore wear and erosion, and flash and blast in small, medium and large caliber tank and artillery weapon systems for improved performance. Specifically, synthesize, characterize and develop test methodologies for nitrogren-doped boron nanotubes/nanofibers (BNNTs/BNNFs) produced using chemical vapor deposition techniques to provide a narrow distribution of diameters. The heat of sublimation of the structures produced will be measured and the materials tested at high flame temperature by incorporation into gun propellants and firing in a wear and erosion tester. Characterization of the BNNT/BNNF based coatings formed inside gun barrels will be conducted.

DESCRIPTION: The Army is interested in reducing gun barrel wear and erosion, and blast and flash characteristics of ammunition in large caliber gun systems by incorporating selected nanoscale additives in propellant formulations. To achieve increased gun performance, high energy propellants are often utilized, the undesirable consequences of which are often increased gun bore wear and erosion, blast and flash. These characteristics are dependent on the propellant formulation thermochemistry and can be tailored to a certain extent by adjusting component compositions and incorporating specific additives. The extensive large caliber gun testing needed to evaluate wear and erosion characteristics is extremely costly (requiring potentially thousands of rounds to be fired). Therefore, it is desired to devise a scalable test protocol that is capable of cost-effectively investigating the erosion, blast and flash characteristics of propellants formulated with nano-additives with comparatively few tests. Some tests devised in the past do not accurately simulate the interior ballistic event and therefore can provide misleading or inaccurate results. To achieve increased gun performance, high energy propellants are often utilized, the undesirable consequences of which are often increased gun bore wear and erosion, blast and flash. Nitrogen-doped boron nanotubes are potentially attractive additive materials for this purpose because of their oxidative stability and hardness relative to carbon-based materials. Like CNTs, BNTs will have strong bonds that will impart high strength to composite materials, whereas nitrogen-doping is expected to further stabilize BNTs and provide even stronger materials.

PHASE I: Down-select and demonstrate the most cost-effective method to produce nitrogen-doped nanotubes/nanofibers with controlled diameters. Protocols for characterization of the nanotubes and nanofibers will be developed to ensure high quality of the materials produced. Scanning electron microscopy should be used to confirm nanotube diameters below 50 nm and transmission electron microscopy coupled with electron energy loss (EEL) and Raman spectroscopic data should be used to confirm that the nanotubes/nanofibers produced are over 95% pure. The heat of sublimation will be determined. During Phase I, develop and design the experimental test methodologies that will be utilized to evaluate the advanced propellant formulations in Phase II. Analytical methods may be utilized to augment the experimental techniques used to evaluate the propellants. Once the experimental test hardware has been designed, some, most or all of it may be fabricated during Phase I, depending on cost. The remainder of the experimental hardware and test fixtures will be fabricated during Phase II. Limited testing can also be performed if resources exist. The composite propellant incorporating the nitrogen-doped nanotubes/nanofibers should have a CO/CO_2 ratio of 2.53-7.78, H_2 /H_2O ratio of 0.40-0.59 and wear not to exceed 18.3-88 mg at 5 msecs.

PHASE II: Optimize and scale up the synthesis process from Phase I. Deliverables must include fabrication optimization and demonstration of a scaled up process for production and detailed characterization in accordance with the plans from Phase I. Large scale gun barrel testing and characterization will be carried out in collaboration with ARDEC and a sub-contractor. Complete the design and fabrication of the experimental hardware identified during Phase I. Evaluate the testing protocol using a limited number of conventional propellant formulations with known characteristics and suitable granulations supplied by the Army or commercial suppliers to establish the feasibility and sensitivity of the protocol in determining propellant wear and erosion, and blast and flash characteristics. Quantify and rank the relative erosion, blast and flash characteristics of the propellant formulations and compare the results with observations from full scale ballistic tests if available (to be supplied by the Army).

Using the test protocol identified during Phase I, including optimization of the nanotube diameter and purity specified above for Phase I, and evaluated during Phase II, characterize the erosion, and blast and flash characteristics of various propellant formulations which contain selected nano-additives. Propellant samples will be provided as GFM by Government laboratories, such as ARDEC, and by commercial propellant manufacturers interested in having their formulations evaluated. Test results will be compared to those of similar formulations that either do not contain nano-additives, or contain additives of identical chemical nature, but of larger more conventional particle sizes. The composite propellant incorporating the nitrogen-doped nanotubes/nanofibers should have a CO/CO_2 ratio of 2.53-7.78, H_2 /H_2O ratio of 0.40-0.59 and wear not to exceed 18.3-88 mg at 5 msecs.

The test matrix will include several baseline propellant formulations modified with nano-additives of different chemistries and quantities. As part of the test protocol, the contractor will recommend the physical granulation of the propellant formulation to be tested based on burn rate and thermochemical characteristics. Conduct the testing protocol developed during Phase I on this enlarged slate of propellants and rank the propellant formulations based on the resulting data. Downselect the field of propellants to two or three promising candidates for continued study and evaluation.

The next step will be to scale the experimental results to the larger caliber gun application in which the propellants will ultimately be utilized (i.e., small arms, medium caliber, tank or artillery). This effort will additionally include the design, fabrication and testing of experimental test fixtures that simulate the larger caliber test requirements. Obtain appropriate granulations of the downselected gun propellant formulations from the Army and/or commercial suppliers for use in the scale testing. Test the downselected slate of propellants in the scaled test fixture(s) and rank them with respect to their relative erosion, blast and flash characteristics.

PHASE III: Partner with DoD Program managers to develop application of these novel nanomaterials in propellant formulations to mitigate gun barrel wear and erosion. Use the experimental test techniques and methodologies developed during the Phase I and II programs to evaluate advanced high performance gun propellant candidate formulations for the military (including Army and Navy laboratories), with nano-additives or otherwise. Characterization of potential replacement propellants with respect to their wear and erosion, and blast and flash for their respective field or fleet applications will save the Military a great deal of money and time pursuing propellants that do not exhibit favorable behavior in representative gun environments[1,2].
For non-military applications, this technology could be applied to the private/commercial firearms industry.

REFERENCES:
1. J. Kunstmann, A. Quandt and I. Boustani, An approach to control the radius and the chirality of nanotubes, Nanotechnology, 18 (2007), 155703.

2. J. Kunstmann and A. Quandt, Broad boron sheets and boron nanotubes: Ab initio study of structural, electronic, and mechanical properties, Physical Review B74 (2006) 035413.

3. Gun Propulsion Technology, edited by Ludwig Stiefel, Progress in Astronautics and Aeronautics, Volume 109.

4. Gun Muzzle Blast and Flash, edited by Gunter Klingenberg and Joseph Heimerl, Progress in Astronautics and Aeronautics, Volume 139.

KEYWORDS: boron nanotubes, boron nanofibers, nitrogen-doped boron nanotubes, gun bore wear and erosion nano-materials, propellant additives, gun bore wear and erosion, secondary flash, propellant chemistry, propellant additives, gun phenomena testing, small, medium and large caliber guns.

A10-045 TITLE: <u>Novel Directed Energy Propagation Methods for Extended Range Operation</u>

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Investigate, design and/or develop innovative method(s) by which directed energy (radio frequency (RF) and/or electromagnetic (EM) can be delivered at tactical ranges without the use of traditional techniques.

DESCRIPTION: As Directed Energy Weapon Systems (DEWS) are being developed for scalable target effects for anti-personnel, anti-material, and countermeasure applications, the size and weight of these systems is one of the most significant barriers to system realization. In order to deliver energy on target at sufficient levels to achieve the desired effects, large radiators or extremely high power sources are required to overcome atmospheric attenuation losses. For example, a one 100 KW class solid-state system (specific operational details are not publishable in open forum) recently designed to engage targets at ranges of less than 100 meters required a 6 meter cargo container, a dedicated generator, extensive heat exchanger system and an antenna system greater than 2 cubic meters. From an operational and logistical point of view, this is unacceptable for most applications.

This topic seeks unique, innovative, high risk solutions to the "one over R squared" issues the DEWS community faces on a daily basis. It is encouraged that the proposed technologies think outside the realm of current methodologies, i.e. larger antennas or bulkier sources. We do not expect that the laws of physics will be broken, but bending them or tricking them to operate in another regime are exciting possibilities.

Proposed solutions should not be frequency dependent. There are applications for extended range DEWS at a number of frequencies or frequency ranges. A common goal across applications is extending that range as far as possible while maintaining or reducing the overall system size. Potential integration opportunities exist in the VHF-UHF Radio bands, as well as in the IEEE Radar Bands designated L, X and W.

The referenced bands of frequency of operation are diverse, and it is very difficult to define specific goals or design metrics in terms of size, weight and footprint. We will evaluate the proposed solutions based on the ratio of power density on target (mW/cm^2) at a range of 100m to the output power of the source. It is acceptable to use a theoretical source in Phase I. Although nearly 10 years old, the primary reference (cited below) is an excellent source of information on militarily relevant sources, output powers and size thereof.

PHASE I: Design a conceptual system that includes detailed analysis of range extension methodology/technology. Indicate potential gains over standard atmospheric losses, and provide initial modeling to corroborate claims.

PHASE II: Develop and demonstrate a prototype system capable of demonstrating long range propagation of RF and/or EM energy. If the developed system is designed to operate at a specific frequency range, Phase II deliverables will also include an analysis of the capability to scale the technology to other frequencies and power levels.

PHASE III: End-state application of this technology is wide-spread throughout DoD and industry. If universally applicable across frequency spectrum, it could revolutionize the battlespace. Directed Energy Weapon Systems would be more effective at current ranges, effective at longer tactical ranges, and less of a logistical nightmare to field and operate.

In the commercial sector, the technology could be applied to all RF communications applications, extending the range of television and radio transmissions, reducing the power requirements to achieve range, and providing higher quality product.

REFERENCES:
1. High-power Microwave Sources and Technologies, Edited by Robert J Barker, Edl Schamiloglu. P. cm. (IEEE press series on RF and Microwave Technology) ISBM 0-7803-6006-0

2. http://www.au.af.mil/au/awc/awcgate/cst/csat10.pdf

3. http://en.wikipedia.org/wiki/Directed-energy_weapon

KEYWORDS: RF, EM, Directed Energy, extended range, propagation

A10-046 TITLE: High Rate High Energy Storage Devices

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this project is to develop new energy storage materials capable of absorbing and delivering large amounts of energy in short periods of time. Phase 1 will investigate the feasibility of various materials, study the ability to absorb energy at very high rates and also deliver large amounts of power to electrical loads. Furthermore, the feasibility studies would provide options for developing and prototyping classes of rechargeable energy storage materials that could be used in munitions power sources to provide the capability of multiple uses in a volumetric efficient format for high power delivery in small and lightweight packages that would meet all military requirements.

Progress has been made in the search for materials and devices that have both a very high power density as well as a very high energy density. Such devices effectively would combine the power density of a capacitor and the energy density of a battery to create the ultimate energy storage medium for portable electronics in general and gun fired munitions in particular. This technology could allow the dumping of a large amount of energy in very short time periods and would allow the simplification of munition power sources from a combination of batteries and capacitors to a single device capable of satisfying the entire power budget. For munitions applications, such a device could be charged completely during the initialization sequence of the round to provide power throughout the entire munition power budget, which would typically last for a few seconds. The energy stored would need to be on the order of 10s of kJs for the intended applications with typical runtimes maxing out on the order of several minutes. Devices capable of meeting these requirements as well as the standard munition environmental requirements would have widespread use among munitions applications.

DESCRIPTION: Power sources for munitions have relatively strict requirements, and consequently are limited to a narrow selection of conventional solutions. These conventional solutions are expensive, large, and will not generally support a significant amount of commercial attractiveness. Reserve batteries are typically utilized in order to meet the 20-year shelf life, but they suffer from reduced power and energy densities because of the separation of electrolyte from the cell, and/or suffer from a limited run time, or power capability depending on the application. It would be desirable to have a device, which could store a large amount of energy over the time period of a few seconds and satisfy the complete munition power budget. Combining the multiple power sources within some munitions maximizes the volumetric efficiency of the munition power source, allowing for high power delivery in small and lightweight package that would meet all military requirements.

This has advantages in munitions since it provides significant flexibility in power system design. Currently, there may be up to three energy storage components in munitions The replacement of these three elements with a single energy storage component would reduce weight and volume and provide system flexibility and would require a rechargeable high power battery with characteristics similar to a high power capacitor but with an energy storage capability of a battery. Identification and production of a suitable high power rechargeable electrochemical power source is the objective of this program. In addition there are operational and military operational temperature requirements (–40 to +145 degrees F), a required shelf life of 20 years and a manufacturability for these power sources. Voltage outputs should extend from a few volts to 2 Kilovolts. There is a lack of suitable solutions to meet the Army munitions needs for rechargeable high power batteries with capacitor-like power delivery capabilities.

PHASE I: Feasibility evaluation of proposed high power high energy storage power will include identification of electrochemical power source materials and suitable engineering architectures to deliver high power and acquire energy at rates similar to high power capacitors. In addition to power delivery performance, capabilities to operate under military conditions – e.g. over wide temperature ranges, and to retain their storage characteristics over a period of 20 years will also be included in the search for suitable chemistries and engineering. The selection will then down select to candidate prototypes for transition to Phase II. The energy storage component will also offer high safety throughout a range of environmental and operational conditions.

PHASE II: Build full-scale rechargeable high power and high energy storage prototypes and test in relevant environments. Demonstrate that prototypes can survive in operational environments while providing voltages from a few volts to up to 2000 volts with the capability of integration into munitions power systems to.

PHASE III: Develop a manufacturing plan for transition from prototypes to low rate initial production. Possibility for application not limited to the realm of munitions. Examples include electric vehicle transportation, high power tools, medical devices, communications and entertainment.

REFERENCES:
1. Encyclopedia of Electrochemical Power Sources, Elsevier, 2009, Ed C. K. Dyer, et al

KEYWORDS: rechargeable battery, high power delivery, capacitor characteristics, shelf life, survivability, safety

A10-047 TITLE: Propulsion System for Confined Space Projectile Launchers

TECHNOLOGY AREAS: Sensors, Weapons

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

OBJECTIVE: Develop and demonstrate a means of launching a projectile from a confined space while maintaining minimum weight, a high muzzle energy, target hit accuracy and safety of personnel in confined space and immediate vicinity.

DESCRIPTION: Military operations in urban terrain of dismounted warfighters requires the use of projectile launchers, typically shoulder-fired, from a confined space, such as a small room or alley, for a variety of tactical operations including armor and bunker defeat missions. Conventional confined space recoilless launchers meeting blast overpressure requirements typically achieve a muzzle energy of 100 KJ and acceptable projectile stability through spin or fin stabilization yet utilize a propulsion devise that is much heavier than desired. To dramatically reduce system weight, new and innovative solutions to propelling a projectile to operational velocities while maintaining personnel safety within a confined space is sought. These solutions must keep weight to a minimum and weigh substantially less than conventional technologies fielded. A typical fire-from-enclosure conventional system configuration utilizes a shoulder-held launch tube to propel an approximately 2.5 Kg warhead to over 300 meters/sec accurately striking a target up to 300 meters distant. These chemical propellant actuated devices, weighing approximately 3 Kg, produce a marginally acceptable blast overpressure when fired from a standardized confined space enclosure. New ideas are sought to launch a projectile from a confined space either within the current systems package of a shoulder-fired launcher or other means while meeting performance and safety requirements. Projectiles from shoulder-fired launchers are usually either rocket motor propelled or driven by expanding burning chemical propellants in a launcher tube with flight stabilization effected by projectile fins or launcher induced spin. Current state-of-the-art confined space launcher propulsion units typically use a chemical propellant driven counter mass which is ejected rearward to counter balance the forward momentum of the projectile. This counter mass may be solid or liquid and may or may not mix with the expanding propellant gases. Personnel safety limits the blast overpressure within the confined space to be within established limits per MIL-STD-1474D. Novel ideas for providing sufficient propulsion while remaining below blast overpressure limits and reducing system weight through any physical process is sought.

PHASE I: Investigate novel or improved conventional means of confined space projectile propulsion to meet operational requirements to include launching a projectile from an enclosed space and striking a target with a terminal energy of 80KJ or greater at a range of up to 300 meters with a probability of hit of at least 0.6. The enclosed space is defined as an enclosure with dimension 12 feet by 15 feet by 7 feet with 20 sq ft of ventilation area. The propulsion system weight shall not exceed 5.0 lbs and not generate pressures within the enclosure exceeding Impulse Noise Limit Z as defined by MIL-STD-1474D. The propulsion system shall not be toxic nor injure the unprotected operator via flash burn, chemical reaction or particle impart when fired from the confined space. The propulsion system shall provide full functionality in the operating temperature range from -40°F to 140°F. The propulsion unit will be used to launch a projectile from a shoulder mounted launcher ranging from between 66mm and 90mm in internal diameter and may use the launcher as a pressure vessel provided internal pressures generated do not exceed 68.9 Mpa anywhere within the launcher. Ignition of the propulsion unit shall be accomplished via an electrical charge from the Launcher with a minimum energy level of 2e-3 J. The propulsion unit shall not generate an impulse forward or rearward to the launcher exceeding 16 N sec. Determine the technical feasibility of these new solutions through analysis and possibly a breadboard demonstration of the basic physics. Demonstrate applicability to current military doctrine and personnel to complete the mission requirements. Develop and initial concept design to show interface with projectile, launcher and fire control system. Deliverables will include a report with detailed description, analyses and design concepts and possibly hardware breadboard prototypes demonstrating technical feasibility and practical applicability.

PHASE II: Develop and demonstrate a hardware prototype to meet operational requirements as defined in Phase I. Perform component and system level tests to quantify system performance in a simulated operation environment and compare to established system metrics including reliability and repeatability. Demonstrate warfighter interface capability and safety acceptability. Deliverables include a final report documenting all design, analyses, manufacturing and testing activities and a detailed plan for further development and transition into a fielded system and/or commercial markets. Deliverables will also include a final inert prototype hardware unit.

PHASE III: The propulsion solutions developed and successfully demonstrated in SBIR Phase I – II will be extended to transition the technology to current and future confined space projectile launcher systems under development within the U.S. Army. One possible application is an extremely lightweight Urban Assault Weapon providing anti-armor, bunker and wall breaching capability as a fire-from-enclosure disposable weapon. Dual use transition to the commercial market may include launcher systems for the law enforcement community for such use as crowd control smoke or tear gas grenade non-lethal launchers. Law enforcement or security personnel may also benefit through the development and marketing of specialized stand-off door or structural wall breeching tools operable from a confined space. The maritime industry may find use of a confined space propulsion unit to launch mooring lines from ship to shore or ship to ship. Avalanche control groups will be able to apply the technology to noise grenades for the safe initiation of snow movement. Aircraft manufacturers may be able to apply this technology to mid-flight deployment of various devices such as emergency parachutes or decoys.

REFERENCES:

1. MIL-STD-1474D, “Department of Defense Design Criteria Standard-Noise Limits”

2. Field Manual 90-10, “Military Operations in Urban Terrain”

KEYWORDS: MOUT, Fire-From-Enclosure, Confined Space, Propulsion, Projectile Launcher, Shoulder-Fired

A10-048 TITLE: <u>Multi-shot EOD Disrupter for Robotic Applications</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Design and build an innovative, electrically-initiated (no mechanical trigger), mechanically actuated, semi-automatic, near recoilless disruption tool for EOD robotic platforms.

DESCRIPTION: The intelligence community and trend analysis suggests that terrorism of the future will continue to include a vast amount of IEDs in their weapons arsenal. The rise in more sophisticated IEDs around the world and the EOD community exploring new disrupters to defeat them become even more critical to successful mission accomplishment. It is imperative that we think ahead and exploit recent technology development to assist the EOD technician in the field.

Current EOD disruption tools provide single shot capabilities ONLY and must be manually reloaded if target reengagement or multiple target engagement is required. That necessitates a return to the safe area, slowing mission effectiveness and straining robot energy resources. There are currently no fielded disrupters that provide a semi-automatic, multi-shot capability. Likewise, there is currently no multi-round device, commercial or otherwise, that can fire multiple EOD water shots (each water shot would necessitate its own barrel, or an innovative way to refill the barrel with water) or withstand chamber pressures (approx. about 27k psi) caused by the standard EOD ammunition this multi-shot disrupter must utilize.

The Joint Service EOD community has a need for a Multiple Round Disrupter capable of firing all Percussion Actuated Neutralizer (PAN) cartridges. This capability would allow for both water shots (blank cartridge firing water) and solid slugs. The Multiple Round Disrupter must be compatible with various robotic platforms and lightweight (5 lbs is desired and 10 lbs is acceptable) to be employed by one EOD technician. Likewise, the recoil force imparted to the robot from the disrupter tool must be negligible (200 lbf or less), and the firing system for the tool must be compatible with the electrical firing circuits currently found on the Foster-Miller Talon and iRobot Packbot robots (16 Volts, 500 milliamps for 2 second duration).

The disrupter must contain a mechanical firing pin, capable of activating the percussion primers of the existing PAN cartridges, but should lack such items as a stock, grip, or mechanical trigger, as it should not be designed for off-hand firing. In addition, the disrupter must also be equipped with a fool-proof (impact and ESD) mechanical safety that is also electrically initiated and must be easily verified by one or more of the onboard robot cameras with little operator effort. The restrictive weight limit placed on the tool may require research into materials other than steel, such as titanium or composites.

PHASE I: Conduct a feasibility study of an electrically-initiated semi-automatic disrupter with built-in recoil force reduction device and able to sustain multiple shot of hot-loaded PAN cartridges (minimum 4 rounds). Provide a detailed report describing the possible conceptual designs that will provide the desired performance.

PHASE II: Design an electrically-initiated (no mechanical trigger) semi-automatic disrupter with little-to-no recoil and capable of firing hot-loaded PAN cartridges (4+ round capacities) without modification to the cartridges. Develop a prototype system and perform preliminary field testing.

PHASE III: Technologies developed under this SBIR can be used for a variety of commercial and government applications. The electrically-initiated disrupter (firearm) technology can be leveraged for future military robotic and remote systems, as well as numerous other applications such as law enforcement, bomb squads, etc. In addition, the technology allowing the disrupter to fire PAN ammunition while being near recoilless, as well as the lightweight materials research, could be leveraged for other firearms.

REFERENCES :

1. Ideal Products, Inc - http://www.idealproductsinc.net/

2. Ideal Products, Inc Price List - GSA Advantage - https://www.gsaadvantage.gov/ref_text/GS07F9146S/0DDPFT.1M8A58_GS-07F-9146S_IDEALGSAPRICELIST121807.PDF

3. http://www.impactguns.com/store/colt.html

4. http://www.barrett.net/firearms

5. http://www.metalstorm.com/component/option,com_frontpage/Itemid,79/

6. http://www.benelliusa.com/

7. http://www.pica.army.mil/pmccs/d2counter/p2eodequipment/SDIED.htm

KEYWORDS: disrupter, disruption tool, firearm, semi-automatic.

A10-049 TITLE: Reactive Materials with Reduced ESD Sensitivity

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The overall objective of this proposal is to design and develop new advanced Reactive Materials (RM) with reduced electrostatic discharge (ESD) sensitivity for ammunition applications. To promote safe handling of this advanced RMs, suitable coating methods will be developed to reduce their electrostatic discharge (ESD) sensitivity. The energetic material will, in general, consist of nanothermite materials and composites thereof. The coated safe material can be both in the form of pallets and powders.

DESCRIPTION: Reactive materials have major defense applications in developing futuristic weapon systems. In an integrated device, energy release at the target are related to the structural components such as payload casing, bomb casing (for fragment formation) etc. If these components can be made out of energetic materials, then, total energy delivered to the target can be increased [1]. Metal-Metal/Oxide (nanothermite) composition in nanoscale is an excellent choice for use as the initiator for secondary energetic materials, because of its ability to exhibit tunable performance and generate high temperatures during chemical reactions between the oxidizer and the fuel [2-5]. The use of thermite materials as a structural element of weapon system can increase energy delivered to the target and increase efficiency of hit the target factor. The synthesis of self assembled nanocomposite consisting of oxidizer and fuel will produce nanoenergetic materials with superior combustion characteristics. One of the key problems preventing the extensive use of this kind of energetic material is the extremely high sensitivity of nanothermites to electrostatic discharge (ESD). Typically values of ESD sensitivity for bare nanothermite composition are less than 1 mJ. Special additives and formulation techniques can increase energy of spark discharge to initiate nanothermite compositions. For example, suitable composition of copper oxide / aluminum nanothermites, selective polymers and electrically conducting materials can pass up to a safe energy level of accidental spark discharge. This level of insensitivity is expected to be acceptable for safe handling such as for military and commercial application. The Electrostatic Sensitivity Test is described in MIL-STD-1751A, dated 11 December 2001, Method 1032, "ESD (Electrostatic Discharge) Sensitivity Test (ARDEC(Picatinny Arsenal)Method)". The formulated sample containing these RM should not react in 20 trials at 0.25 joule (the maximum energy level of the test apparatus) if used in HE applications. Pass/Fail safety criteria for primary, booster, or main charge explosive formulations are listed in MIL-STD-1751A including: impact sensitivity, friction sensitivity, electrostatic sensitivity, stability at constant temperature, self-heating, compatibility, detonation velocity, critical diameter, shock sensitivity, hot wire ignition, exudation and growth safety tests.

PHASE I: Development of Reactive Materials and evaluation of their performance in terms of combustion wave speed, pressure, reactivity and ESD Sensitivity will be undertaken in the Phase I. The formulations will be developed for composites of nanothermites with polymers, explosives and electrically conducting polymers. The novel materials should produce desired combustion performance and safe handling level. The integration of nanothermite composition with advanced materials like carbon nanotubes, graphite nanoparticles etc will also be carried out. The phase I plan will include development of the right combination of materials' compositions and optimize their synthesis procedures to solve the most important problem (high ESD sensitivity of bare nanothermites) limiting the practical use of the nanothermite compositions. The proof of concept will be established during this effort. If the optimized formulations including these RMs pass the ESD test according to the pass/fail criteria stated in MIL-STD 1751A for any or all of the specified applications (ie. booster explosives, primary explosives, etc.), Phase II can begin.

PHASE II: Systematic investigation of the performance and aging studies of the developed RMs with reduced sensitivity in Phase I will be performed The Scale-up of the most successful composition preparation technology to produce 1-50 pounds (lb.) of advanced RMs in the shape of pallets and powders for testing at ARDEC Facility and its affiliates in this cooperative program will be explored in Phase II.

PHASE III: Commercialization of the technology will be undertaken in the third phase through strategic partnership. Other than defense needs, the business plan is expected to include dual-use applications as for military and commercial technology.

REFERENCES:
1. "Advanced Energetic Materials", Committee on Advanced Energetic Materials and Manufacturing Technologies, National Research Council, ISBN: 0-309-09160-8, 64 pages, 8 1/2 x 11, (2004) Source: http://www.nap.edu/catalog/10918.html and the references therein.

2. MRS Proceedings Volume 896: "Multifunctional Energetic Materials", 2006 and the references therein.

3. Richard H. B. Bouma, Denise Meuken, Ries Verbeek, Maria Martinez Pacheco, and Laurens Katgerman, "Shear Initiation of Al/MoO3-Based Reactive Materials", Propellants, Explosives, Pyrotechnics 32(6), 2007, 447 – 453.

4. Prakash, A., McCormick, A.V, Zachariah, M.R "Thermo-kinetic study of core-shell nanothermites", 845 II, 2006, 1006-1009 AIP Conference Proceedings

5. Puszynski J.A, Buhan, C.J. Swiatkiewicz, J.J, "Processing and ignition characteristics of aluminum-bismuth trioxide nanothermite system". Journal of Propulsion and Power 23(4) 2007, 698-706.

KEYWORDS: Nanoenergetics, Nanothermites, ESD sensitivity, Reactive Materials, Coating methods, Performance, Aging

A10-050 TITLE: <u>Application of Nanothermite based Modified Composition as Propellant Initiator</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Design, develop and demonstrate the suitability of employing nanothermite-based pyrotechnic composition as a primer in propellant system for effective and fast response time of action.

DESCRIPTION: The concept of application of nanothermite composition in the perspective munitions' systems is very attractive. Metal-metal oxide (nanothermite) exothermic reaction generates very high reaction temperature up to 4000K in comparison to less than 1000 K for nitro-based primer composition. The significance of modified nanothermite compositions over conventional primer compositions is the ability to generate extremely high temperatures during reactions. The Copper oxide – aluminum, iron oxide – aluminum and molybdenum oxide – aluminum compositions can be considered as base materials for propellant initiation compositions. Typical combustion wave speed of pure nanothermite materials is around 500-2000 m/s. Such bare nanothermite materials exhibiting high combustion wave speed are not suitable for pyrotechnic and propellant initiation application. To increase both the pressure and the flame impact time for definite ignition of secondary propellant, modified nanothermite composition comprising of gas generating polymers and bare nanothermite is being proposed [1-5]. More importantly, these polymers also reduce the high sensitivity of nanothermite primer composition to electro static discharge (ESD). Typical value of ESD energy for pure nanothermite is less than 1 mJ whereas the ESD energy of polymer modified nanothermite compositions can be tuned up to 125 mJ without compromising on their desired combustion characteristics. Such high values of ESD energy will allow safe handling of nanothermite based primer compositions preventing any accidental ignitions. Successful model experiments for initiation of JA2 pellet by iron oxide / aluminum / polymer composition demonstrated the proof of the concept.

PHASE I: The Synthesis and investigation of Fe2O3/Al composition with suitable nitro-content polymer to control the burn rate, maximum pressure, sustained pressure duration will be undertaken for propellant initiation application. Physical and chemical characterization of materials will be performed. The overall technology process of synthesis of modified nanothermite material system will be developed and documented.

PHASE II: The Scale-up methods of synthesis of suitable nanothermite material system for primer applications will be explored. The proof of principle of the design will be demonstrated by showing the data from model experiments. Testing will be conducted to demonstrate the feasibility of the proposed initiation composition for operation with a given real propellant-based system. The data from model initiation experiment in lab scale will be analyzed. The comparison of the initiation data from the nanothermite-based composition with the currently-used primer material systems (such as Benite) will be evaluated.

PHASE III: The optimized nanothermite primer will be incorporated into real munitions and the functionality of the whole system will be widely tested. The performance features of nanothermite compositions will be evaluated for future applications. The new materials and technology developed under this effort are anticipated to have use in a wide variety of civilian applications beyond defense fields such as an automotive and aviation security system, process surface treatment, mining applications, etc. The commercialization aspects of dual-use applications will be undertaken in this phase through strategic partnership.

REFERENCES:
1. Son, S.F. Asay, B.W., Foley, T.J. Yetter, R.A., Wu, M.H. Risha, G.A,” Combustion of nanoscale Al/MoO3 thermite microchannels”, Journal of Propulsion and Power, 23(4) 2007, 715-721.

2. Diaz, E., Brousseau, P., Ampleman, G., Emery Prud'homme, R. Polymer nanocomposites from energetic thermoplastic elastomers and Alex®. Propellants, Explosives, Pyrotechnics, 28 (4), 2003, 210-215.

3. Gransden, J.I., Taylor, M.J. “Study of confined pyrotechnic compositions for medium/large calibre gun igniter applications”, Propellants, Explosives, Pyrotechnics, 32(6), 2007, 435-446.

4. Son, S.F., Yetter, R.A., Yang, V. “Introduction: Nanoscale composite energetic materials”, Journal of Propulsion and Power 23(4), 2007, 643-644 and the references therein.

5. “Advanced Energetic Materials”, Committee on Advanced Energetic Materials and Manufacturing Technologies, National Research Council, ISBN: 0-309-09160-8, 64 pages, 8 1/2 x 11, (2004) Source: http://www.nap.edu/catalog/10918.html and the references therein.

KEYWORDS: Propellant Initiator, Pyrotechnic, Primer, Nanoenergetics, Nanothermite, Energetic Polymer, ESD-sensitivity

A10-051 TITLE: Novel Combustible Polymer Cased Small Arms Ammunitions

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop and test lightweight combustible polymer cased small arms ammunitions to replace brass cased ammunitions without sacrificing ballistic performance and long-term reliability.

DESCRIPTION: Weapon system advances have resulted in the infantry soldiers carrying additional gear to enhance their combat effectiveness, but at the cost of increased logistics burden. To ensure that America’s soldiers maintain their overwhelming combat edge into 21st century, decreasing soldier loads has moved to the top of the priority list in the Army. In this regard, one of the heaviest load pieces for soldiers is their ammunition. However, the high cost of lightweight metal materials and the associated manufacturing costs represent a significant part of the affordability challenge faced by these efforts. Attempts in the past 50 years to use lightweight polymers to replace brass can only reduce the weight by about 25% and has not yet proven successful to achieve the ballistic performance and long-term reliability. Combustible cartridge case technology is successfully used in large caliber ammunition systems to eliminate the logistical burden of disposing of unconsumed packaging after firing. Combustible cartridge cases bring additional advantages in comparison to metallic cartridge cases or old bag charges such as reduction in barrel wear, enhanced firing energy, increased firing rate and reduction in charge costs. At the same time the combustible polymer case materials offers protection of the propellant charge in the handling, storage, and loading phases, making it the better candidate to replace metallic packaging than caseless cartridges.

Recently there is significant interest to pursue combustible cartridge case technology in small caliber weapon systems to achieve the lightweight ammunition goal. However, it is challenging to apply the combustible cartridge technology used in large caliber ammunitions to small arms ammunition to replace the conventional brass case. The technical hurdles include the combustible resin inherently lacking mechanical strength, high porosity, vulnerability to penetration of water and water vapor, and problems related to materials used for fabrication, and complete combustion. Therefore, despite numerous advantages of the combustible cased cartridge to the conventional metal cased cartridge, enough attentions should be given to characterizing the potential problems associated with the production and use of combustible cases.

The program shall accomplish specific performance objectives. A multidisciplinary research and development effort, focusing on mechanics, materials science, physics, chemistry, design and numerical modeling and simulations, shall be conducted to identify and characterize the combustible polymer materials, optimize small caliber cartridge case design, as well as production feasibilities. First, this effort shall develop or identify combustible polymer materials for polymer cartridge case applications. Included in this development is the study of the material residue after burning of the selected combustible polymeric materials. Analysis on mechanical and physical properties of the combustible materials at various temperature, humidity and treatments shall be performed. Secondly development efforts for small arms cartridge case design using combustible polymer materials shall be carried out. Dynamic finite element analysis simulations to validate the internal and exterior ballistic performance of the proposed cartridge case designs shall be conducted. Lastly, investigations on the environmental effects on the mechanical and physical properties of the selected combustible polymer materials shall be accomplished. Assessment of the production capabilities and feasibilities of the proposed lightweight combustible polymer cased small arms ammunitions need to be addressed.

The success of this combustible small arms cartridge case technology will deliver the lightweight ammunition solution to US Army. By reducing the ammunition weight, solders can have the same or more fire power with a stronger armor protection and additional gear without compromising their mobility, thus achieving tactical objectives and protection of our soldiers.

The novelty of this topic is that it addresses small caliber munitions. While the technology to implement combustible cartridge casing is mature for large caliber munitions, there is little work done on small caliber munitions. While the state of the art is NC based cartridge cases, and there is current work being performed with cellulose based cartridge casings, it is difficult to apply them to small combustible cartridge casings. These materials have low mechanical strength, high porosity, they are vulnerable to water infiltration, they can leave behind some residue (especially in the case of non ideal combustion), and they are difficult to fabricate into small cartridges. While these problems are largely unimportant for large caliber munitions, for small caliber they are critical. Even small amounts of residue and water infiltration will jam small arms, while such degradation would largely be unimportant with large arms. Ongoing R&D is focused on developing and implementing large caliber combustible cartridge cases. This SBIR provides a unique opportunity to invest in the development of small caliber combustible cartridge munitions which present an interesting problem, largely independent of large caliber combustible cartridge casings. This SBIR will address not only novel materials, but novel methods of manufacturing and processing of these materials as well.

Parameters/Metrics which these cartridges must meet:
* The cartridges should exhibit little to no porosity, and must be completely hydrophobic
* The material used to fabricate the charges should be relatively easily formed into the desired shapes
* The cartridges must be made of a material 25% mechanically stronger than currently used in combustible cartridge cases in large caliber munitions.
* No residue should be left behind after combustion.
* The ballistic performance of the new rounds should be 10% superior to legacy rounds.
* The weight should be 50% of that of legacy rounds.
* There should be no toxicity issues with the cartridge.
* The cartridges should be able to withstand standard operating conditions.
* Aging should not have significant effects on the performance or safety of the cartridge cases.

PHASE I: Develop novel small arms cartridge case design concepts using combustible polymer materials. Conduct dynamic finite element analysis simulations to validate the internal ballistic performance of the proposed combustible cartridge case designs. Identify, develop and test combustible polymer materials for small arms polymer cartridge case applications. Study the material residue after burning of the selected combustible polymeric materials. Perform analysis on mechanical and physical properties of the combustible materials at various temperature, humidity and treatments.

PHASE II: Review the results from the Phase I feasibility study. Optimize the combustible material selections and refine the cartridge case designs. Investigate environmental effects on the mechanical and physical properties of the selected combustible polymer materials. Develop proper tooling and molds and build actual prototype cases on proposed combustible small arms cartridge case designs. Conduct advanced 3-D finite element analysis modeling and simulation to validate the ballistic performance of the proposed cartridge case with combustible material at extreme low temperature or cook-off temperature in hot weapon chamber. Conduct ballistic testing to measure chamber pressure and muzzle velocity and inspect the residue material. Assess production capabilities and feasibilities of the proposed lightweight combustible polymer cased small arms ammunitions.

PHASE III: If this program is demonstrated to be successful, this combustible polymer casing technology can be applied to military and civilian applications. Military application includes lightweight cartridge cases for small arms (5.56mm, 7.62mm and .50 calibers), medium caliber (20mm, 25mm, 30mm and 40mm) as well as large caliber (60mm, 81mm, 105mm and 120mm) ammunitions. Civilian application includes ammunitions for hunting and law enforcement.

REFERENCES:
1. Chesonis, Kestusis G.; Smith, Pauline M.; Lum, WIlliam S., “Investigation of Residue and Coating Stoichiometry on 120-mm Combustible Cartridge Cases”, US Army Research Laboratory, Aberdeen Proving Ground, MD 21005, ARL-TR-2337, 2000,

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

3. Hannum,, J. A. E., Editor, “Hazards of Chemical Rockets and Propellants”, Volume 2, Solid Propellants and Ingredients, Chemical Propulsion Information Agency, Laurel, MD, CPIA Pub. No. 394, Vol. II, Jun 1985, p. 11-3, CPIA Abstract No. 86-0027, AD A160 812

KEYWORDS: Structural, energetics, lightweight, ammunition

A10-052 TITLE: Innovative Heavy-lifting Manipulators for EOD Robots

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: Develop an innovative high-strength dexterous manipulation system that utilizes innovative gripping and lifting technologies for the small robotic platforms used by Explosive Ordnance Disposal (EOD) to investigate and interrogate Unexploded Ordnances (UXOs) and Improvised Explosive Devices (IEDs).

DESCRIPTION: Over the past couple of decades, EOD warfighters have benefitted from the use of unmanned ground vehicles (UGV) class of robots to investigate and neutralize improvised explosive devices (IEDs) and unexploded ordnances (UXOs). These small UGVs currently have only one arm with low degree-of-freedom (DOF) manipulators, primitive controls and light-weight lifting capability. The dexterity of currently fielded manipulators allows for only basic maneuvers, often requiring the operator to compensate for this deficiency by moving the UGV base to perform the manipulation task. This places a significant cognitive burden on the operator. The motors, motion controllers, and control software of currently fielded arms also typically produce imprecise, unsmooth motions. These primitive controls make teleoperation of the arms extremely challenging, and require the operator to have a high degree of skill. These rudimentary controls also make it nearly impossible to automate the current arms for more advanced, semi-autonomous behaviors. These robots can only perform one task at a time. This limitation prevents the robot from performing dangerous tasks such as removing blasting caps or initiating devices from an IED while holding onto or making sure the rest of the IED does not move. This shortcoming may require the EOD technician to physically approach and manually neutralize the IED, exposing them to situations which could cause harm to the technicians. Finally, current arms on these small UGVs offer minimal lifting ability, making it impossible to lift commonly encountered items used as IEDs, such as a 155mm shell. Fairly dexterous manipulators have existed for decades within the Industrial Automation market. This market, which typically has no size, weight, power, or dynamic loading constraints, has led to the creation of manipulators that have excellent performance at their tasks, but are typically big and heavy, utilize large off-board computing cabinets, require heavy-duty current draw, and are not designed to endure the shock loads typically encountered on a mobile robot. Unfortunately, these designs cannot be simply ported to small UGVs, especially UGVs which the EOD technicians currently use.

This SBIR topic is seeking innovative gripping and lifting technologies addressing each of these major shortcomings, providing a highly dexterous, heavy-lift manipulator with smooth, predictable control. This system will also offer a solution that is highly intuitive for a human operator to control.

The solution should be able to: 1) have the dexterity to manipulate small items such as blasting caps and wires, while have the capability to lift a 155mm projectile weighing up to 120 lb, 2) utilize advanced materials such as composites and custom power-dense actuation technologies to produce a system with an objective target weight of 30 pounds or less, allowing it to be employed by the EOD small UGV class robot, 3) intuitively control arm(s), torso and end effectors, 3-DOF for the torso, and a variety of end effectors (desired to have 8-DOF but not required), 4) the controller must be simple and easy to use to offer a natural means to control each joint and end effectors.

PHASE I: Conduct a feasibility study to design a high-strength dexterous manipulation system and identify means to intuitively control the system to augment the capabilities of the currently fielded EOD robots. Provide a detailed report describing the possible conceptual designs that will provide the desired strength, dexterity, agility, and force-to-weight ratio.

PHASE II: After optimizing the modeling and simulation of Phase I findings, develop and demonstrate a functional prototype of the advanced manipulation system.

PHASE III: The ultimate goal of this research is to provide an innovative manipulation system for use on currently-fielded EOD robotic platforms. Provide an open architecture interface, such as JAUS version 3.3 or AS4, to facilitate integration onto existing or future robotic platforms. This system will also have the potential for application in other mission areas such as Combat Engineers and Infantry. With certain modifications this system would also be capable of being integrated into the next-generation Advanced EOD Robotic System (AEODRS) or small UGVs of the future Brigade Combat Team Ground Combat Vehicle Program. Commercial applications could be applied in routine police and fire EOD work situations and warehouse storage requirements.

REFERENCES:
1) The Defense Technical Information Center (DTIC) website: http://www.dtic.mil/dtic/

2) Optimal, Model-Based Design of Soft Robotic Manipulators, J. Mech. Des. -- September 2008 -- Volume 130, Issue 9, 091402

3) Hydraulic Robot Manipulator Shoulder, http://www.cim.mcgill.ca/~haptic/pictures/Shoulder.html

4) Force Feedback Manipulator, http://www.ameasol.com/grips.pdf

5) Hydraulic end effector, http://www.vecnarobotics.com/multimedia/downloads/end_effector.pdf

6) http://www.foster-miller.com/lemming.htm

7) http://www.irobot.com/sp.cfm?pageid=109

8) MIL-STD-1472F, Human Engineering and DOD-HDBK-743A, Anthropometry of U.S. Military Personnel

KEYWORDS: IED defeat, VBIED detection, hydraulics, robot manipulators

A10-053 TITLE: Nanostructured Magnesium Composites for Lightweight, Structural Applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop process to produce fully dense, nanostructured, magnesium-based composites for lightweight, structural military and non-military applications.

DESCRIPTION: Mg and Mg alloys are characterized by a very low density and high specific properties, have an inherently high ability to dampen mechanical and acoustic vibrations, and have extremely high thermal conductivities. Bulk nanocrystalline materials have typically exhibited significant increases in strength and hardness compared to conventional coarse-grained materials. Further strengthening may be achieved through the dispersion of fine, nanometer-scale reinforcement. The goal of this SBIR is to design and develop new nanostructured, magnesium-based composites with tensile strengths greater than 600 MPa (87 ksi) and tensile failure strain greater than 5 % at room temperature.

It is believed that the development of a fully dense, nanostructured, Mg-based composite reinforced with carbon nanotubes (CNTs) will result in a lightweight, high strength, structural composite with unique properties. It is believed that the successful incorporation of CNTs will serve to greatly enhance the specific properties, since CNTs have a low density, and high elastic modulus and tensile strength. It should further enhance the materials damping capability, since carbon and graphite are well-known damping agents in a variety of materials, and presents opportunities to develop unique thermal management schemes for the composite. The size scale of the CNTs may lead to conductivities that positively depart from conventional mixture rules; theory predicts non-linear conductivity enhancements as the size of a second phase within a composite matrix decreases.

The challenge is to design Mg-CNT formulations and develop a process to consolidate the powder blend formulations into a homogeneous, fully dense composite with nano-grain structure. As such, techniques that use nano or nano-grained powders and consolidation techniques that can be used to preserve the microstructure of the starting powder and achieve a nanostructured composite are of special interest.

PHASE I: Design a formulation for a magnesium alloy reinforced with CNTs and demonstrate a process to produce a homogeneous, fully dense composite with average grain size less than 200 nm. Fabricate small test specimens (minimum cross section 1/4" x 1/4" or 1/4" diameter) and characterize the mechanical properties (in accordance with ASTM E8) of the composite under quasi-static conditions. The entrance criteria to be invited for a Phase II will be achieving a specific tensile yield strength of approximately 300 MPa*g^-1*cm^3).

PHASE II: Determine optimal CNT content with respect to mechanical properties, and produce a homogeneous, fully dense composite further reducing the grain size to less than 100 nm. Characterize the mechanical and thermal properties of the composite under quasi-static and dynamic conditions (0.001/s-10,000/s). Scale up the process to produce 4" x 4" tiles for ballistic testing by US Army.

PHASE III: The material developed under this effort will have dual use applications in military as well as commercial applications. The material can be inserted/transitioned into several Army hardware programs for ground and air vehicles. Commercial potential includes aerospace and law enforcement applications.

REFERENCES:
1. Q. Li, A. Viereckl, C.A. Rottmair and R.F. Singer, “Improved Processing of Carbon Nanotube/Magnesium Alloy Composites,” Composites Science and Technology, Vol. 69 (2009) 1193-1199.

2. E. Carreno-Morelli, J. Yang, K. Hernadi, J.W. Seo, C. Bonjour, L. Forro and R. Schaller, "Carbon Nanotube/Magnesium Composites," Phys. Stat. Sol. (A), Vol. 201 (8) (2004) R53-R55.

3. Y. Shimizu, et al., "Multi-Walled Carbon Nanotube-Reinforced Magnesium Alloy Composites," Scripta Materialia 58, (2008) 67–270.

4. Y. Kawamura, et al., "Rapidly Solidified Powder Metallurgy Mg97Zn1Y2Alloys with Excellent Tensile Yield Strength above 600 MPa", Mater. Trans. Vol 42 (2001) 1172.

KEYWORDS: Magnesium composites, nanostructured composites, carbon nanotubes, structural materials, powder consolidation

A10-054 TITLE: Innovative Non-conventional Imaging Technology for Situational Awareness

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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

OBJECTIVE: Research and develop innovative nonconventional technology to enable inexpensive, zero latency, hemispherical visual display of the area around manned vehicles to the personnel therein without placing them in harm's way.

DESCRIPTION: Situational awareness around manned vehicles is critical for the protection of soldiers in urban and mountainous terrain war environments. Such environments are complex 3-dimensional arrays of obstructions that are very capable of hiding the enemy. For moving manned vehicles the environment and the threat is constantly changing. Threats can appear momentarily and disappear as rapidly. Conventional optical devices such as cameras can miss transient threats due to possible frame rate restrictions and lack of resolution covering ranges from close to long distances from the vehicle.

This solicitation is for research, development, and implementation of innovative nonconventional technologies that are robust in a war environment, that are relatively inexpensive, and that provide immediate imaging of the visual sphere around the vehicle. The innovative technology should be cheaper than conventional cameras, provide spatial resolution that is limited only by the human eye, and provide zero latency between an event and the observation of the event. The nonconventional technology should provide continuous hemispherical imaging and use a maximum of 2 watts of power to operate during daytime hours. This innovative solution must not put the occupants at risk by allowing outside observers to see them or by compromising the structural integrity or the ballistic properties of the vehicle. The solution must spectrally transmit 90% or more of the energy from at least 400 nanometers to 1 micron. The system, in production quantities, should cost less than $50,000.

PHASE I: Research and develop innovative, nonconventional technology for use in the optical path to facilitate inexpensive, immediate, and continuous monitoring of the visual sphere around manned vehicles by the occupants. The optical resolution must be such that a soldier looking at a viewing screen can identify targets such as personnel and individual weapons from the edge of the vehicle to a distance of at least a kilometer. Light loss by the system should be less than 10% in the visible region through the near infrared region. The optical elements in the path should occupy less volume than traditional digital cameras used on current vehicle platforms and should be ruggedized to withstand military vehicle environments.

PHASE II: Design and fabricate an innovative prototype meeting the above criteria. Demonstrate that the system provides 90% transmission from 400 nanometers to one micron. Demonstrate the system's spatial resolution, continuous hemispherical coverage, and image latency between the exterior of the vehicle and the occupant. Demonstrate the power and size requirements. The system design should be such that installing the system on a vehicle would not require any major modification to the vehicle.

PHASE III: Initiate actions for commercialization of the system within the DOD. Install the system on an Army vehicle. Such a system might also be used for fixed site platforms and enhanced to perform spherical imaging for an aerial based platform. Other DoD applications might include drones, airplanes, and Navy boats. Commercial applications could include security systems for retail outlets, parking lots, warehouse storage areas, etc.

REFERENCES:
1. Donald M. Chiarulli, Steven P. Levitan, et. al, Multichannel Optical Interconnections using Imaging Fiber Bundles, Appl. Opt. 39, pp698-703 (2000).

2. S. K. Nayar, V. Branzoi, and T. E. Boult, Programmable Imaging: Towards a Flexible Camera, International Journal on Computer Vision, Oct, 2006.

3. S.K. Nayar, V. Branzoi and T. Boult, Programmable Imaging using a Digital Micromirror Array, IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Vol.I, pp.436-443, Jun, 2004.

4. http;//www.dtic.mil/ provides many hits on micromirrors and fiber optic arrays.

5. http://www.ceramoptec.com/products/sub_content.asp?SubnavID=14&ThirdNavID=5

6. http://www.olympus-ims.com/en/fiberscope/

7. http://www.ronanmeasure.com/pages/images/Fill-Fluid%20vs%20Fiber%20Comparison.pdf.

KEYWORDS: Fiber optic bundles, digital micro-mirrors, imaging, situational awareness, Digital Micro-mirror Devices, fiberscopes

A10-055 TITLE: A large field-of-view and high resolution camera in a small form factor

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: Design, develop and demonstrate a small form factor camera to provide a high resolution image capture over a wide field of view to enable significantly higher detection and classification of unexploded ordnance.

DESCRIPTION: Miniaturized small and light weight cameras that have a large field-of-view (FOV) and that maintain the same image quality throughout the FOV are needed for many applications, including military, homeland defense and commercial applications. Although large FOV imaging systems have been demonstrated recently, achieving high spatial resolution and a large FOV simultaneously still remains as a challenge. Generally, the captured images in these systems suffer from distortions caused by off-axis aberrations. Alternatively, multiple images can be obtained from using an array of lenslets, each lenslet capturing a low resolution image of the scene and applying superresolution techniques to reconstruct a single high resolution image. This approach may prove good enough for some applications. Further, some of the large FOV imaging systems using mirrors and lenses may tend to be bulky and costly. In developing a large FOV camera one may derive useful hints from biological imaging systems, in particular, from the compound eyes of insects. However, compound eyes, while having a large FOV, suffer from poor image resolution.

In general, image resolution in optical systems is subject to a fundamental limit of resolution known as "Abbe's diffraction limit," according to which the best resolution that can be achieved is approximately lambda/2 where lambda is the wavelength of light. The reason for the Abbe's limit in resolution stems from the fact that the evanescent light from the object, which carries the sub-lambda information of the object's features, decay exponentially as a function of distance from the object. As a result, only the propagating waves those carrying the low frequency spatial components (coarser details) are collected at the image plane. Superresolution imaging beyond Abbe’s diffraction limit can be achieved by utilizing an optical medium or ‘metamaterials’ that can either amplify or transport the decaying near-field evanescent waves that carry subwavelength features of objects. Such materials typically have one or more of their permeability or permittivity components that are negative. These metamaterials can be artificially engineered and fabricated using controlled nanofabrication techniques and offer the possibility of restoring or recovering the lost sub-lambda object features thereby making a high resolution image with little degradation. While superresoultion may perhaps be achieved by post processing of the collected images, the advent of the negative metamaterials offer for the first time the scope for developing optical components to achieve subwavelength imaging capabilities. Research also indicates the promise for metamaterials that are tunable over wide frequency ranges.

This solicitation calls for the design and development of a small form factor camera to provide a wide field of view image capture with high resolution. Novel solutions that make use of the advent of new and innovative optical materials are expected to be considered to break the fundamental barrier of achieving resolution across a large FOV. One of the challenges of this topic is to design cameras that would operate over a wide wavelength range that includes but not limited to visible to near infrared (400-900nm) and short wavelength infrared (900-1700nm).

PHASE I: Demonstrate a proof-of-concept design to fabricating a small form factor camera using novel material and lens concepts that would offer high resolution wide field of view image capture. The proof-of-concept design should take into account size, weight and power (SWaP) of such a camera keeping in view its ultimate use in soldier hand-held and robotic applications and in smart munitions. The camera should have at least 180 degree by 90 degree field of view. Trade-off studies are to be performed to arrive at the best combination of field of view, resolution and sensitivity and yet maintaining the SWaP requirements. In one of the intended applications of locating small objects of interest, it is expected that the camera could achieve superresolution wide field of view image capture at reasonable depths to detect unexploded ordnance (UXO) (1 foot nominal depth) from standoff distances of approximately 25 feet or less.

PHASE II: Develop and demonstrate a prototype small form factor camera that will simultaneously realize wide field of view and high resolution. Demonstrate the capability to achieve the high resolution image such that the camera can track objects rapidly moving at varying ranges. The prototype should have size, weight and power (SWaP) features that are commensurate with its intended operations in a hand held or robot mounted applications. Additionally, it is envisioned that a small form factor sensor/camera can be included in smart precision tactical/protective networked munitions. Ideally, the image collection and image recognizing functions in the small form factor camera would have the SWaP features of a cell phone camera (example: size of 10x10mm and power consumption of the order of 120 mW). The camera should have at least 180 degree by 90 degree field of view and should offer subwavelength resolution in the operating wavelength ranges. The camera should operate over a wide wavelength range that includes but not limited to visible to near infrared (400-900nm) and short wavelength infrared (900-1700nm). A prototype small form factor camera shall be delivered at the end of Phase II.

PHASE III: The high resolution small form factor camera developed under this effort will have immediate application of detection of UXOs. It will have dual use applications in all surveillance related missions. Further, it can find applications in smart precision munitions guidance and navigation as well as in target sensing. Smaller and lighter sensors with a wide field of view and high resolution in smart munitions can provide enhanced battlefield intelligence both in tactical and protective operations. Homeland Security Operations not limited to Border Patrol, airport security, Federal Emergency Management Agency and perimeter protection surveillance operations can benefit from the small, high resolution small form factor camera that can detect rapidly moving objects over a wide field of view. The camera can be mounted on robotic platforms and can acquire high resolution images from areas which would prevent human intervention such as in buildings with fire and/or those infested with biological, chemical, nuclear agents. These robots can also be deployed in operations requiring remote surveillance applications.

REFERENCES:
1. "Foveated wide field-of-view imaging system using a liquid crystal spatial light modulator," T. Martinez, D.V. Wick and S.R. Restaino, Optics Express, vol. 8, p.555-560 (2001).

2. E. Abbe, Arch. F. Mikroskop. Anat. 9, 413(1873).

KEYWORDS: Small form factor camera, wide field of view, high resolution

A10-056 TITLE: Affordable GPS-independent Precision Munitions

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Integration

OBJECTIVE: Develop an innovative, low-cost, GPS-independent, and high-G-survivable alternative guidance and control sensor for precision munitions.

DESCRIPTION: Guidance and control systems for precision munitions consist of a processing unit, appropriate sensors and seekers, and a software application that can determine the desired trajectory of a projectile and make mid-course corrections to hit a target.

Current guidance and control components used in precision munitions are very expensive, which is the primary impediment to their mass fielding. Another challenge to fielding a large number of precision munitions is the fact that few guidance and control sensors are able to survive high-G firing accelerations of up to 20,000 G. Current guidance and control sensors rely on GPS for accuracy, if GPS is jammed or not available these guidance sensors cannot meet the Excalibur target Circular Error Probability (CEP) requirements. Furthermore, current systems have high power consumption, requiring power sources that occupy a large portion of the warhead volume.

This SBIR effort solicits innovative ideas to be evaluated through a series of feasibility studies, resulting in a proven solution that can be inexpensively integrated into munitions like the Excalibur round in a mass production scenario (see Reference (1, 2, 3, 4).

The objective of this SBIR project is to provide a gps-independent inertial sensor suitable for the Excalibur round. This objective must be met while achieving a design that reduces the production cost of the sensor package to below $1000 (see references 1, 2, 3, 4). This innovative, low-cost sensor must meet current Excalibur requirements for Accuracy on Target CEP (Circular Error Probability) of 10 meters in a GPS-denied situation. The proposed system must provide high G survivability in the range of 20,000 G. Reducing the power requirement for this sensor will likely be an important factor in achieving the objective of this project (low power consumption for current inertial guidance sensors is in the range of 3 to 4 watts at 5 volts). Candidate proposals need to focus on how the guidance sensor is being used to supply accurate error data to the guidance and control algorithm.

PHASE I: Perform feasibility studies for the proposed solutions to determine their potential to satisfy project objectives. Develop analytical models and perform computer simulations to determine the characteristics and the performance of each intertial sensor concept. Based on the metrics listed in the description, justify the selection of a concept to develop under the Phase II effort.

PHASEII: Develop and demonstrate the selected sensor solution in a prototype guidance and control package suitable for the Excalibur round. Perform structural integrity tests, including an air gun test, to illustrate survivability. Perform laboratory tests and range tests to validate the developed models and to confirm the performance of the sensor in a guidance and control package.

PHASE III: Based on test results, develop an optimally designed guidance and control package with integrated sensors for integration into the selected round in preparation for test firing. Upon maturing the technologies, the prototype hardware developed and demonstrated by means of field tests will be inserted into relevant acquisition strategies such as Army Technology Objectives, or Naval and Air Force programs. The development of an optimally designed guidance and control package has a wide range of military, homeland security and commercial applications. In military applications, highly affordable guidance and control packages will enable the mass production of multiple gun-fired munitions, missiles, and smart bombs. Other military applications could include robotic platforms widely used in security and special hazardous missions. For commercial applications, affordable guidance packages and their components can be used in industrial automation, robotics, precision machines, automated transportation, the automobile industry and the commercial space industry.

REFERENCES:
1. Honeywell gun-hard inertial measurement unit (IMU) development. This paper appears in: Position Location and Navigation Symposium, 2004. PLANS 2004. Publication Date: 26-29 April 2004. On page(s): 49- 55. ISSN: ISBN: 0-7803-8416-4

2. Excalibur, XM982 Program, 6th International Cannon Artillery Firepower Symposium, http://www.dtic.mil/ndia/cannon/hansen.pdf

3. Development of the XM982 Excalibur Fuzing System, NDIA 49th Annual Fuze Conference http://www.docstoc.com/docs/15061778/XM982-Excalibur-Merged-Program

4. Low Cost, High G, High Accuracy, MEMS IMU Coordinated, Development and Manufacturing Effort for Common Guidance, https://www.dodmantech.com/successes/Army/army_Low_Cost_High-G-MEMS_IMU-ds.pdf

5. A local position measurement system with integrated telemetry channel, Stelzer, A. Pourvoyeur, K. Fischer, A. Gassenbauer, G. This paper appears in: Radio and Wireless Symposium, 2006 IEEE Publication Date: 17-19 Jan. 2006, page(s): 91 – 94, ISBN: 0-7803-9412-7

6. A new efficient algorithm for analyzing and optimizing the system of sensors, Fijany, A. Vatan, F. , Jet Propulsion Lab., California Inst. of Technol., Pasadena, CA, paper appears in: Aerospace Conference, 2006 IEEE Publication Date: 0-0 0, On page(s): 8 pp., Location: Big Sky, MT, ISBN: 0-7803-9545-X

7. Overview of automotive sensors, Fleming, W.J., Syst. Technol., TRW Occupant Safety Syst., Washington, MI, USA; This paper appears in: Sensors Journal, IEEE ?Publication Date: Dec. 2001, Volume: 1 , Issue: 4, On page(s): 296 – 308, ISSN: 1530-437X, CODEN: ISJEAZ

8. Integrated Guidance and Control of Missiles With $theta hbox – D.Method. Ming Xin Balakrishnan, S.N. Ohlmeyer, E.J., Dept. of Aerosp. Eng., Mississippi State Univ., Starkville, MS, This paper appears in: Control Systems Technology, IEEE Transactions on Publication Date: Nov. 2006, Volume: 14 , Issue: 6, On page(s): 981 – 992, ISSN: 1063-6536

9. Sensor selection and motion planning in robotic sensor networks under communication constraints Muhammad, A. Sch. of Comput. Sci., McGill Univ., Montreal, QC, This paper appears in: Decision and Control, 2008. CDC 2008. 47th IEEE Conference on Publication Date: 9-11 Dec. 2008, On page(s): 3107 – 3112, Location: Cancun, ISSN: 0191-2216, ISBN: 978-1-4244-3123-6

KEYWORDS: Low cost, low power, smaller form factor, high G survivable, Inertial Measurement Unit, Global Positioning System, smart and precision gun fired munitions, fuzing systems

A10-057 TITLE: Dynamic Conditioning of Projectiles for Ultra-Lightweight Armor Applications

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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, demonstrate, and evaluate promising materials, processes, and technologies to achieve improved Soldier and vehicle ballistic protection through dynamic softening of the projectile nose to reduce penetration.

DESCRIPTION: A common utilized method to defeat armor-piercing small and medium caliber ballistic projectile threats involves the utilization of ceramics such as aluminum oxide, boron carbide, and silicon carbide that are backed by metal plates. The ceramic materials are usually bonded onto metal and/or composite backings with low-density, low-impedance, and low shear strength adhesives. The primary ceramic properties exploited are high strength and hardness to rapidly fracture the penetrator on the hard ceramic surface after impact. The subject of understanding the dynamical failure modes of these materials and penetration mechanics of threat projectiles are areas of intense investigation that will allow for the development of new solutions for protection. In anticipation of new and/or unforeseen threats as they emerge, continual improvements in armor systems are necessary. Beyond the revolutions in materials technologies that design engineers may come up with, alternative means of improving armor systems are required.

It is understood that the effectiveness of ceramic armor can be increased if the penetration capability of the threat projectile can be dynamically altered (blunted or deflected in some manner). Therefore, the focus of this program is to explore methods for enhancing the performance of ceramic armor through the development of advanced materials and/or processes that synergistically work together to blunt or deflect small projectiles. Critical technology areas to be addressed include blunting, deflection, delamination, and bonding. New innovative concepts are sought that can dynamically blunt projectiles. Examples include: (1) New materials and/or processes that are integrated to precede the ceramic armor exterior front surface that can interact with the projectile upon impact with sufficient response time, heating to deform or blunt. The response would need to react sufficiently fast to heat the projectile as it passes through the system. Activation would need to be enabled by the impact of the projectile on the materials and/or process. (2) Deflection mechanisms or materials capable of reacting sufficiently fast and with assymetrical volume expansion to deflect a projectile as it begins to penetrate the front surface. (3) Delamination materials or mechanisms from within a laminate ceramic composite designed to cause delamination and buckling of ceramic plates such that their motion deflects the tip of an incoming projectile. The materials and/or process would need to react sufficiently fast to produce delamination and buckling before the projectile penetrated into the second layer of the laminate, armor composite. (4) Bonding or brazing materials and mechanisms placed on the exterior of ceramic armor to enable bonding of braze like materials to the tip of an incoming small projectile. The bonding process would be designed to add mass to and thereby blunt the tip of the projectile, and in turn, minimizing penetration.

The primary objectives are to conceive, devise, model, fabricate, and experimentally validate advanced concepts and configurations that may be able to defeat ballistic projectile threats. The advanced concepts and configurations must able to achieve and exploit dynamic conditioning mechanisms in <100 microseconds. The advanced concepts and configurations must lightweight and able to be scaled for portability in the future. The advanced concepts and configurations will be evaluated against a baseline armor configuration.

PHASE I: Define, design, and analyze promising protection technologies that have the potential to dynamically soften the nose of a projectile upon ballistic impact and reduce projectile penetration by 25% versus an equivalent thickness of silicon carbide. The advanced concepts and configurations must able to achieve and exploit dynamic conditioning mechanisms in <100 microseconds. The advanced concepts and configurations must lightweight and able to be scaled for portability in the future. The advanced concepts and configurations will be evaluated against a baseline soldier or vehicle armor configuration.

PHASE II: Design, fabricate, and test both new advanced materials and dynamic processes to validate performance and applicability. Dynamic performance evaluations will be conducted at the Army Research Laboratory at no additional cost to the contractor. The advanced materials and dynamic processes must demonstrate improved ballistic performance in a prototype lightweight protection system.

PHASE III: The developed technology will be inserted into Army ATO Program TWV -"Tactical Wheeled Vehicles" and transitioned to PEO-CSS, PEO-Soldier, and DARPA. Technology will also be jointly integrated into Navy and Air Force protection programs.

REFERENCES:
1. Anderson, C. "Developing an Ultra-Lightweight Armor Concept." Ceramic Armor Materials by Design (Ceramic Transactions, Vol. 134), pp 485-498, 2002.

2. Franks, L.P. ed., "Advances in Ceramic Armor IV: Ceramic Engineering and Science Proceedings", Volume 29, Issue 6, Wiley, ISBN: 978-0-470-34497-2, December 2008

3. J.W. McCauley ed., "Ceramic Armour Materials By Design, (Ceramic Transactions, Volume 134), The American Ceramic Society, Westerville, Ohio, 2002 (ISBN 1-57498-148-X).

4. V. Parameswaran, et.al., "A new approach for improving ballistic performance of composite armor", Experimental Mechanics, Springer Link, Volume 39, Number 2, June, 1999.

KEYWORDS: ballistic protection, active protection, low power, man-portable, lightweight armor, vehicle protection, soldier protection, body armor, survivability

A10-058 TITLE: Development of a Two Color Polarimetric Forward Looking Infrared (FLIR) Camera System

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a ruggedized forward looking infared (FLIR) video-imaging system capable of measuring and displaying in real-time, calibrated Stokes imagry and associated products, in both the MidIR (3-5µm) and LWIR (8-12µm) regions of the IR spectrum, i.e., two color operation.

DESCRIPTION: Polarimetric imaging (PI) is the generation of a 2D image (or video) whose pixel intensity is directly related to the polarization state of the image forming light. This novel imaging methodology has been explored to varying degrees in the past where the primary mode of operation was limited to the visible or NIR regions of the spectrum.(1-4) However, there has been recent development within the DoD and private sector research communities in which a series of "research-grade" LWIR and MidIR polarimetric imaging sensor systems have been developed.(5-8)

Sensors that operate in the thermal IR are designed to exploit the phenomena that man-made objects emit thermal radiation that tends to have a preferential polarization state (usually linear), while naturally occurring "background" materials, e.g., vegetation, grass, trees, etc., tend to show little or no preferential polarization. As a result, a thermal polarimetric image can significantly enhance the ability to detect certain targets by increasing the contrast between a man-made object and their respective background, while simultaneously suppressing any irrelevant clutter. Example applications for using polarimetric imaging in the thermal IR include: detection of disturbed earth and/or altered road-type surfaces, enhanced targeting and tracking of man-made vehicles and personnel, and the identification and suppression of decoy objects.(9-12)

However, in order to realize the full tactical benefit for using thermal polarimetric imaging on the battlefield (or for civilian applications), new ruggedized and cost-effective sensor platforms must be developed. Prospective candidates should be familiar with the current state-of-the-art polarimetric filtering techniques, as well as the advantages (and disadvantages) inherent with each optical design, i.e., division-of-focal-plane (sometimes termed micro- or super-pixel) approach, division-of-aperture (DOA), division-of-amplitude (DoAmP), and division-of-time (or spinning achromatic retarder) approach. Similarly, since polarimetric imaging relies on differencing two images (or video streams) image misregistration error must be kept below 1/10 pixel.

In addition, because the thermal polarimetric signal results from either "emission" dominated polarization as seen in LWIR, or "reflection" dominated polarization as often seen in the MidIR, it is desirable to operate in both IR bands simultaneously in order to maximize the information content from the resulting 6 channels, i.e., a conventional radiance image for each band, and a pair of polarimetric Stokes images, S1 and S2, for each band. By being able to separate and distinguish between two IR regions in a polarimetric image that are either reflection or emission dominant, one gains a significant amount of new information about the composition and nature of the target(s) and its environment.(13,14) Additional rational for two color operation are outlined in an earlier paper by Howe.(15)

Therefore, the proposed polarimetric FLIR system must satisfy the following minimum operational criteria: 1) capture and record a minimum of 4 video channels, e.g., conventional thermal Mid and LWIR channels, and 2 (user specified) polarimetric channels, say, S1(Mid) and S1(LWIR), 2) display in near realtime, user specified 2 or more fused thermal/polarimetric channels, e.g., create a mask with one channel and superimpose it on second channel, 3) complete camera system must result in less than 1/10 pixel misregistration error between difference images, and 4) FLIR system must exhibit a rugged and portable design capable of combat type operation.(16,17) Additional parameters such as size, weight, choice of a particular focal-plane-array(s) (FPA), cooled or uncooled operation, power consumption, etc., will be left to the discrepancy of the proposal author(s). Major criteria for evaluation will include maximizing polarimetric/radiometric signal-to-noise, ease of use, and sensor ruggedization.

PHASE I: Identify all optical components and conduct radiometric/polarimetric ray tracing calculations to predict expected throughput and identify aberrations. Identify specific FPA(s) and vendors required for dual-band operation. Identify/design all required computer processing hardware, frame-grabber, circuit and A/D boards, etc., as well as software to be used for both mathematical computations and real-time multichannel video fusion and display. Outline detailed polarimetric calibration procedures.

PHASE II: Assemble, test, calibrate, and demonstrate prototype device as described in Phase I. Measure and quantify image misregistration error. Testing should include measurement of the overall modulation transfer function (MTF) as well as the polarization MTF (PMTF). Upon completion of a working prototype, the system will be delivered a government research facility for demonstration and assessment of specific system capabilities. Such capabilities will include: a) remote detection of disturbed earth, b) detection of low observable targets, c) identification and suppression of decoy targets, d) remote detection of camouflaged objects, and e) the use of resultant polarimetric imagery to enhance performance of established automated target recognition (ATR) system(s).

PHASE III: Examples of nonmilitary applications for IR polarimetric imaging include: 1) ice detection on planes, roads and bridges, 2) detection of low observable objects, i.e., oceanic search and rescue, 3) remote sensing and identification of various geological features such as crop conditions and detection/monitoring of sea contaminants, 4) nondestructive testing in various manufacturing processes, and 5) noninvasive detection of sublayer metallic corrosion.

REFERENCES:

1. O. Sandus, "A review of emission polarization," Appl. Opt. 4, 1634–1642 (1965).

2. R. Walraven, "Polarization imagery," Opt. Eng. 20, 14–18 (1981).

3. J. Wolfe and R. A. Chipman, "High-speed imaging polarimeter," in Polarization Science and Remote Sensing, J. A. Shawand, J. S. Tyo, eds., Proc. SPIE 5158, 24–32 (2003).

4. J.S Tyo, D. Goldstein, D. Chenault, J. Shaw, "Review of passive polarimetry for remote sensing applications", Appl. Opt. vol. 45, no. 22, pp.5453-5469 (2006).

5. M. Kudenov, L. Pezzaniti, G. Grant, "Microbolometer-infrared imaging Stokes polarimeter", Optical Eng. Vol. 48 no. 6 June (2009).

6. J. L. Pezzaniti and D. B. Chenault, "A division of aperture MWIR imaging polarimeter," Proc. SPIE 5888, 58880V (2005).

7. C. A. Farlow, D. B. Chenault, K. D. Spradley, M. G. Gulley, M. W. Jones, and C. M. Persons, “Imaging polarimeter development and application,” in Polarization Analysis and Measurement
IV, D. H. Goldstein, D. B. Chenault, W. Egan, and M. J. Duggin, eds., Proc. SPIE 4819, 118–125 (2001).

8. D. Bowers, J. K. Boger, L. D. Wellens, W. T. Black, S. E. Ortega, B. M. Ratliff, M. P. Fetrow, J. E. Hubbs, and J. S. Tyo, "Evaluation and display of polarimetric image data using long-wave cooled microgrid focal plane arrays," in Proc. SPIE vol. 6240: Polarization: Measurement, Analysis, and Remote Sensing VII, D. H. Goldstein and D. B. Chenault, eds., p. 6240OF SPIE, Bellingham, WA, (2006).

9. K.P. Gurton, M. Felton, “Detection of disturbed earth using passive LWIR polarimetric imaging” Proc SPIE Optics and Photonics Conference, San Diego, Ca. August 2-6, (2009).

10. C. An, J. Grantham, J. King, J. Robinson, L. Pezzaniti, K. Gurton, “Utility of Polarization Sensors for Clutter Rejection”, 6th Annual US Missile Defense Conference, Washington DC, March 31-April 3, (2008).

11. K.P. Gurton, M. Felton, “Detection of buried Improvised Explosive Devices (IED) using passive long-wave infrared (LWIR) polarimetric imaging”, ARL Technical Report, ARL-TR-4941 Sept. (2009).

12. J. S. Harchanko, D. B. Chenault, C. F. Farlow, and K. Spradley, “Detecting a surface swimmer using long wave infrared imaging polarimetry,” in Photonics for Port and Harbor Security, M. J. DeWeert and T. T. Saito, eds., Proc. SPIE 5780 (2005).

13.R. S. Loe and M. J. Duggin, “Hyperspectral imaging polarimeter design and calibration,” in Polarization Analysis, Measurement, and Remote Sensing IV, D. H. Goldstein, D. B. Chenault, W. G. Egan, and M. J. Duggin, eds., Proc. SPIE 4481, 195–205 (2002).

14. S. Tyo, B.M. Ratliff, J. Boger, W. Black, D. Bowers, M. Fetrow, “The effects of thermal equilibrium and contrast in LWIR polarimetric images”, Opt. Express, vol. 15, no. 23 Nov. (2007).

15. J.D Howe, “Two-color infrared full-Stokes imaging polarimeter development”, Aerospace Conference, 1999 IEEE, vol. 4, pp. 79-85, 6-13 March (1999).

16. Although 4 channel operation is specified as a minimum (i.e., 2 radiance and 2 polarimetric channels), capture and processing of all six channels is most desirable, i.e., MidIR, LWIR, S1(mid), S1(LWIR), S2(mid), and S2(LWIR).

17. J. S. Tyo, E. N. Pugh, and N. Engheta, “Colorimetric Representations For Use With Polarization-Difference Imaging Of Objects In Scattering Media,” J. Opt. Soc. Am. A 15, 367–374 (1998).

KEYWORDS: Polarimetric imaging, infrared, Stokes imagry, disturbed earth detection, improvised explosive device (IED) detection, long-wave infrared (LWIR), Mid-wave infrared (MidIR), two-color IR, duel-band IR

A10-059 TITLE: E-Field Warhead & Projectile Technology

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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

OBJECTIVE: To discover, develop, and integrate innovative technologies to concurrently couple the energy from electric fields into both structural warhead and projectile cases and explosives providing compact munitions capable of achieving focused and scalable lethal and non-lethal effects against targets.

DESCRIPTION: Current Army weapons utilize a wide range of small, medium, and large caliber ammunition, projectiles, warheads, mortars, rockets and missiles. These are recognized as the world's most lethal and survivable weapons, but it is understood that they must rapidly evolve to meet the needs of the Soldier in the ever-changing theaters of conflict in an increasingly urbanized world. The presence of manmade structures, limited engagement areas, restrictive maneuver space, the presence of noncombatants, and the ability to effect resource denial to enemy forces occupying the urban area without completely destroying the resource infrastructure are factors that can limit the use of certain weapons. The Army has identified the need for weapons that span the full range of multifunctional capability that can be tailored to the target, result in low collateral damage, provide overwhelming lethality, and/or non-lethal effects.

There are ongoing efforts to develop warhead and projectile technologies such as selectable fragmentation and controlled blast to provide scalable and adaptive lethal effects against targets. There are also extensive ongoing parallel efforts to develop new classes of weapons capable of providing non-lethal effects. Through this work, the state of weapons technology for urban warfare has improved, but is far from optimal. It is also apparent that increased numbers of specialized munitions are on the horizon to fill these needs, and will likely result in increased burdens on the supply and logistical chains. Significant technology gaps must be overcome to enable truly multifunctional and multipurpose compact weapons that can singularly provide the full range of desired effects.

The goal of this effort, which may be an important leap in this direction, is the development of new technologies that combine, augment, or control the chemical energy provided by explosives with electrical field energy and concurrently drive dynamical processes within the munitions case. It has been shown that electromagnetic pulses, produced by explosive detonation (chemical energy conversion to electromagnetic energy) in a configuration known as a electrical flux compression generator (EFCG), can be utilized to provide non-lethal effects (mega amps that damage and/or disable electronics). Also, within the extreme pressure, chemical reaction region of a detonation event of an explosive, ionized intermediates within the electron rich environment preceding the shock front, are electrically conducting. Therefore, electrical energy coupled into the reaction zone of the detonation wave may increase and/or augment explosive chemical energy and output (e.g. control detonation pressure, tailor blast, alter fragment velocity, etc). Selective-controlled activation and switching of the EFCG, as the munition case itself, might lead to preferential mass and energy focusing (directional effects), focused lethal effects (all one direction), destruction of case (non-fragmenting), and/or electromagnetic pulse only. This technology might also allow for the use of very insensitive or inexpensive low-grade explosives where performance could be boosted as needed. The overarching technical challenges are to (1) develop a fundamental understanding of the chemical, physical, and engineering aspects of electric field augmentation of dynamic explosive events, (2) identify phenomena that control the partitioning of electrical energy into the detonation front , (3) elucidate approaches and activation mechanisms enabling electrical field control of munition structural cases for selective spatial and temporal directional effects, (4) identify mechanisms for optimum conversion of explosive energy to electromagnetic effects, (5) develop concepts and approaches for integrating these technologies into a single device capable of providing focused lethal and non-lethal effects, (6) perform numerical modeling to describe and predict properties, (7) determine efficacy and scaling parameters, including size limitations, for configurations in 155mm, 120mm, 105mm, 81mm, 60mm, 30mm, and 25mm diameters, and (7) experimentally evaluate the most promising configurations. There is also great potential for the use of very compact explosively driven electromagnetic field devices for a variety of pulsed power applications and for dual-use applications for precision focused effects in mining and demolition.

PHASE I: Define and design new concepts for to concurrently couple the energy from explosively driven electric fields into both structural warhead and projectile cases and explosives. Utilize modeling and simulation or other numerical tools to determine approaches which achieve >10% coupling of electrical energy into explosive, >30% conversion of explosive energy into electrical energy, and >50% mass selectable and directional focusing from warhead and/or projectile in configurations (e.g., 155mm, 120mm, 105mm, 81mm, 60mm, 30mm, and 25mm diameters). Define and design new concepts to develop extremely small explosively driven devices for pulsed power generation and electromagnetic field generation.

PHASE II: Fabricate prototype devices to be tested in baseline 155mm and 60mm configurations to validate ability to achieve >10% coupling of electrical energy into the explosive; >30% conversion of explosive energy into electrical energy; and >50% mass selectable and directional focusing. The ability to most efficiently couple electrical energy into the explosive and convert explosive energy into electrical energy is a higher priority than mass and directional focusing from the device. Perform analysis addressing affordability, producibility, and manufacturability plans for new materials. Fabricate prototype explosively driven compact devices and demonstrate & quantify pulsed power output; and demonstrate electromagnetic field generation in small portable devices.

PHASE III: The developed technology will be inserted into Army ATO program STAR – "Scalable Technology for Adaptive Response" and transitioned to PEO-AMMO, PM-MAS, PEO-Missiles & Space, DARPA, and acquisition programs. Technology will also be jointly integrated into Navy (Office of Naval Research), DTRA, and Air Force (Eglin Air Force Base Munitions Directorate) munitions programs, and also commercialized for military utilization. The same technology will have large dual-use applications for very compact explosively driven devices with precision-focused output for mining and demolition for close-quarters work where explosives output needs to be carefully controlled to avoid unwanted damage to surrounding infrastructure. Very compact explosively driven devices that produce high peak-current will have dual use applications for pulsed power (acctuators, explosive bolts, explosively powered portable cutting tools). Compact explosively driven electromagnetic fileld generators will have applications for electronics defeat (stopping vehicles, disabling electronics, disabling IEDs).

REFERENCES:
1. Explosively Driven Pulsed Power Helical Magnetic Flux Compression Generators, By Andreas A. Neuber (ed), Library of Congress Control Number: 2005926342, ISBN-10 3-540-26051-X Springer Berlin Heidelberg New York, ISBN-13, 978-3-540-26051-6 Springer Berlin Heidelberg New York.

2. Basmanov V.F. et al, "Resistive 100 MJ MCG with radial line- Matreshka-640. Megagauss Magnetic Field Generation and Pulsed Power Applications.
Ed. Cowan M. and Spielman R.B. – New York: Nova Science Pub., 1994.,P. 455-458.

3. Novac, B.M., et al, "A fast and compact Z-pinch electromagnetic flux-compression generator" J. Phys. D: Appl. Phys. 37 (2004) 3041–3055.

KEYWORDS: Explosive, electric field, warhead, projectile, scalabe effects, lethal, non-lethal

A10-060 TITLE: <u>Fabrication of High-Strength, Lightweight Metals for Armor and Structural Applications</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Development a manufacturing methodology to produce large-scale lightweight, high-strength ultrafine-grained (UFG) alloys for potential armor and structural applications.

DESCRIPTION: With recent global developments has come the increased recognition of the need to develop and implement lightweighting strategies for the full range of weapons platforms (land, sea, and air) without a loss in platform functionality. Lightweight ultrafine-grained (UFG) alloys have shown tremendous increases in strength and ductility over conventional coarse-grained, conventionally process materials, but have primarily been researched at laboratory (cm) scales. Furthermore, the typical scales at which the materials have been produced have excluded the possibility of ballistic evaluation. This proposal aims to fill this void by soliciting optimized UFG materials for likely armor applications, and also, investigating the scale-up and prospective commercialization of the methods used to manufacture such a material. The ability to achieve the desired mechanical properties on a large scale through novel processing approaches has the potential for high-impact and near-term applications. These significant improvements in the mechanical and physical properties of UFG lightweight metals will drive design of lightweight metal structures and armor components in military vehicles, thus reducing large logistical burdens, minimizing operational constraints and liabilities, and reducing vulnerabilities.

PHASE I: The results of Phase I will be five (5) lightweight alloy and/or composite plates for metallurgical, mechanical and ballistic characterization. Innovative equipment and processing methodologies may need to be developed to achieve plates with the following criteria: specific density less than 3 g/cm^3, average grain size less than 0.500 micrometers, ultimate tensile strength greater than 450 MPa, relative tensile elongation greater than 8%, minimum plate size of 300 mm x 300 mm x 25 mm.

PHASE II: Phase II will culminate in the research and development of processing methodologies to provide scaled-up plates with a minimum size 1.25 m wide x 3.5 m long x 25 mm thick which meet or exceed the same standards as determined by Phase I. Some of these panels will be rolled out into wider panels or sheet products. This will be paralleled by continued metallurgical and mechanical testing, and assessment of commercial scalability. Technology Readiness Level (TRL) 5 should be attained by the end of Phase II and continued funding should be at 6.3/6.4 levels.

PHASE III: The production of high strength sheet and plate product could see an abundance of applications in both military and civilian realms. The probable military applications span from lightweight personnel protection (e.g. E-SAPI vest back-plates) to large armor packages. High-strength, lightweight sheet product would find its way into the civilian market as preform for sheet-formed items or perhaps vehicle body panels. The transitions to operational capability to achieve these prospective applications will be based on a transition between the Phase I research and development to achieve property goals, to the scale-up feasibility in Phase II, and then commercial production in Phase III. At the end of Phase II, program managers responsible for manufacturing and armor materials specification in military vehicles will evaluate the potential for transition.

REFERENCES:
1. Ruslan Z. Valiev, Rinat K. Islamgaliev, Igor V. Alexandrov, Bulk nanostructured materials from severe plastic deformation, Progress in Materials Science, v.45, p. 103-189, 2000.

2. Terry C. Lowe and Yuntian Zhu, Commercialization of nanostructured metals produced by severe plastic deformation processing, Advanced Engineering Materials, v.5, p. 373-378, 2003.

3. Yuntian Zhu, Terry C. Lowe and Terence G. Langdon, Performance and applications of nanostructured materials produced by severe plastic deformation, Scripta Materialia, v.51, p.825-830, 2004.

4. Vladimir M. Segal, Engineering and commercialization of equal channel angular extrusion (ECAE)", Materials Science and Engineering, A., v.386, p. 269-276, 2004.

5. Stephane Ferrasse, Vladimir M. Segal, Frank Alford, Janine Kardokus and Susan Strothers, "Scale-up and application of equal channel angular extrusion for the electronics and aerospace industries", Materials Science and Engineering, A., v.493, p.130-140, 2008.

KEYWORDS: Ultrafine Grained Material, Aluminum, Magnesium, Strength, Armor, Manufacturing Processes

A10-061 TITLE: <u>Formation of large single crystals of aluminum oxynitride (AlON) ceramic</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop and demonstrate a process for the growth of large aluminum oxynitride (AlON) transparent single crystals in the cubic crystal class, with high purity and perfection such as those suitable for optical or microelectronic applications. A process for the manufacture of large ALON single crystals will also play a vital role in enabling the validation of ab initio and molecular dynamics calculations of AlON anisotropic elastic constants.

DESCRIPTION: This effort would develop and demonstrate a process for the formation of large single crystals (50 mm diameter x 25 mm thick) of aluminum oxynitride, AlON, material which is a dense transparent armor ceramic being considered for windows in armored vehicles and semiconductor applications [1,2]. Current AlON material is formed from pressed, cast or molded powder which is then densified by heating in an oven. In this polycrystalline form, individual crystals are on the order of 200 microns in size, and are of cubic spinel structure. Polycrystalline aluminum oxynitride is commercially known under the name ALON(trademark) (see e.g. www.surmet.com). Large single crystals of gamma-AlON are needed that appear on the pseudo-binary AlN-Al203 (aluminum nitride-aluminum oxide) phase equilibrium diagram as described in [3].

PHASE I: The phase I objective will develop and demonstrate a process for growing large single crystals of AlON with stoichiometry (about 30-35% mole percent AlN) ideally centered at Al8(CN IV) Al15(CN VI) AluminumVacancy(AlVI)O27 N5 as described in [3,4,5]. Crystals grown in Phase I should be sufficiently large (> 2 mm3), optically transparent and isotropic, and nearly free from defects so that resonant ultrasound spectroscopic (RUS) methods [6] can be used to independently determine the ambient cubic elastic constants, (C11, C12, C44), for the material. Deliverables for Phase I will include:
1) Develop and demonstrate a process for growing single crystals of AlON (> 2 cubic millimeters)
2) Crystals should have real in-line visible light transmission of 80% and the degree of optical transparency using a UV-VIS-IR transmission curve with > 70 percent transmittance.
3) Demonstrate that the single crystals are optically isotropic.
4) Measure cubic elastic constants (C11, C12, C44) for the single crystal material using RUS or other method.
5) Write a final report describing the Phase I crystal growth process specifications, which incorporates all information in 1) – 4) above.
6) Deliver five (5) single crystals (> 2 cubic millimeters) to ARL.

PHASE II: Phase II will demonstrate that the process can be scaled up to grow larger single crystals of AlON (50 millimeter diameter x 25 millimeter thick).
Deliverables for Phase II will include:
1) Develop a process capable of scaling up the Phase I effort to grow AlON single crystals (50 mm diameter x 25 mm thick).
2) Crystals should have real in-line visible light transmission of 85% and the degree of optical transparency using a UV-VIS-IR transmission curve with > 70 percent transmittance.
3) Demonstrate that the Phase II single crystals are optically isotropic.
4) Measure and compare the cubic elastic properties of crystals grown using Phase I (>2 cubic millimeter) using RUS techniques with Phase II, (50 mm diameter x 25 mm thick) using pulse echo or other techniques.
5) Measure and compare the dielectric properties of crystals grown using Phase I (>2 mm3) with those in Phase II, (50 mm diameter x 25 mm thick).
6) Write a final report describing the Phase II crystal growth process specifications, which incorporates all information in 1) – 5) above.
7) Develop a viable technology transition plan.

PHASE III: The technology developed under this program if successful can be used on a number of Army and commercial applications that require large optical windows, domes, and plates, substrates for microelectronic applications, and the solution will be applicable/usable by any and all aircraft in the Department of Defense inventory.

REFERENCES:
1. E.K. Graham, W.C. Munly, J.W. McCauley, and N.D. Corbin, “Elastic properties of polycrystalline aluminum oxynitride spinel and their dependence on pressure, temperature, and composition,” J. American Ceramic Soc., V. 71, No. 10, 897- 812, 1998.

2. N.D. Corbin, “Aluminum oxynitride spinel: A review,” J. Eur. Ceram. Soc., V. 5, 143-154, 1989.

3. J.W. McCauley, “Structure and properties of AlN and AlON ceramics,” Elsevier’s Encyclopedia of Materials: Science and Technology, Elsevier Science, Ltd. 127-132, 2001.

4. C.M. Fang, R. Metselaar, H. T. Hintzen, and G. de With, “Structure models for gamma-aluminum oxynitride from ab initio calculations,” J. Am. Ceram. Soc., V. 84, No. 11, 2633–2637, 2001.

5. I.G. Batyrev, B.M. Rice, and J.W. McCauley, “First principles calculations of nitrogen atomic position effects on elastic properties of aluminum oxynitride (AlON) Spinel, MRS Fall Meeting, Boston, MA, 30 Nov – 3 Dec, 2009.

KEYWORDS: Cubic crystal class, aluminum oxynitride, resonant ultrasound spectroscopy, AlON, transparent armor ceramic, large single crystals.

A10-062 TITLE: Inexpensive Large Scale Manufacturing of High Specific Modulus and Strength Ceramic Fibers

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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

OBJECTIVE: Develop and demonstrate an inexpensive large scale high output manufacturing process to fabricate high specific modulus and high specific strength continuous ceramic fibers. The continuous ceramic fiber must be suitable to be used in a variety of existing conventional textile weaving processes without a modification for downstream aluminum (Al) and/or magnesium (Mg) based metal matrix composites (armor) fabrications.

DESCRIPTION: Continuous ceramic fibers have a wide range of potential engineering applications in civil and military sectors. However, their limited processability and high cost hampers their utilizations in such applications. Currently, extremely limited commercially viable continuous ceramic fiber processing techniques exist. The focus of the current SBIR is to design, develop, and demonstrate an inexpensive and highly scalable manufacturing system suitable to process high specific modulus and high specific strength continuous ceramic fibers. The output continuous ceramic fibers must be suitable to be directly fed into a variety of existing conventional fiber textile weaving processes without significant modifications for downstream lightweight Al and/or Mg metal matrix composites (armor) applications. Orders of selection criteria of this SBIR topic are (1) specific modulus, (2) specific strength, (3) batch quantity, (4) cost, and (5) all others.

PHASE I: Design and develop one or more continuous ceramic fiber synthesis methodologies, demonstrate its compatibility with Al and/or Mg based metals, and demonstrate its manufacturing feasibility by producing ceramic fibers with the following characteristics as minimum requirements: specific modulus > (larger than) 135 GPa/g/cc; specific tensile strength > (larger than) 140 MPa/g/cc; fiber (single fiber or filament) diameter = (less than or equal to) 25 micrometer; fiber length to diameter ratio > (larger than) 1000; batch quantity > (larger than) 0.5 lb; and cost analysis < (less than) $1000/lb.

PHASE II: Scale up the ceramic fiber synthesis methodologies demonstrated during the Phase I without degrading the compatibility with Al and/or Mg based metals. Build one or more prototype semi-continuous ceramic fiber manufacturing system; demonstrate its effectiveness by producing ceramic fibers with the following characteristics as minimum requirements: specific modulus > (larger than) 135 GPa/g/cc; specific tensile strength > (larger than) 140 MPa/g/cc; fiber (single fiber or filament) diameter = (less than or equal to) 15 micrometer; semi-continuous in fiber (single fiber or filament) length suitable to form commercial size spools of 5000 (+/- 2500) denier strands; batch quantity = (equal to or larger than) 25 lb in commercial size spools of 5000 (+/- 2500) denier strands ; and cost analysis < (less than) $100/lb.

PHASE III: Transition the manufacturing technology to civil and military sector applications. The manufacturing technology transition to military applications includes partnerships with major MMC armor plate manufacturers, armor integrators, and/or DoD prime vehicle integrators. Deliverables and technical data packages resulted from this SBIR will support a variety of ATOs, MTOs, and Army PMs and Army PEOs for Army warfighters and vehicle survivability.

REFERENCES:

1. B. Moser, A. Rossoll, L. Weber, O. Beffort, and A. Mortensen, "Damage Evolution of Nextel 610™ Alumina Fibre Reinforced Aluminium", Acta Materialia 52 (2004) 573-581.

2. D.M. Wilson, "Statistical Tensile Strength of Nextel™ 610 and Nextel ™ 720 fibers", Journal of materials Science (1997) 2535-2542.

3. H.J. Dudek, R. Leucht, and J. Hemptenmacher, "Thermal Stability of SiC-SCS-6 Fiber-Reinforced IMI834 Alloys", Metallurgical and Materials Transactions A (1996) 1403-1405.

4. X. Ning, P. Pirouz, and S.C. Farmer, "Microchemical Analysis of the SCS-6 Silicon Fiber", Journal of the American Ceramic Society (1993) 2033-2041.

KEYWORDS: Continuous ceramic fibers, high specific modulus, high specific strength, large scale manufacturing, metal matrix composites armor applications

A10-063 TITLE: Cast Encapsulation of Unfinished Ceramic Armor Tiles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The purpose of this proposal is to establish an alternative metal encapsulation mechanism of unfinished ceramic tiles that will provide the Army with a greatly reduced cost option for legacy and future platforms within the current repertoire for armor solutions. This purpose with be accomplished by leveraging existing design, modeling, and newly established manufacturing technology (MANTECH) capabilities against well known established manufacturing practices with large US industrial capacity employing existing metal alloy systems; systems that lack expensive elements, that are not environmentally prohibitive, or are sensitive due to their strategic alloy element acquisition. A low-cost manufacturing process is sought that will directly cast the encapsulated ceramic structure to net/near-net shape and eliminate ceramic tile finishing practices currently required for existing ceramic panel designs.

DESCRIPTION: The casting process must produce sound parts where the metal encapsulating structure must be intact, crack-free, and of a structural metal (Mg, Al, Ti, or Fe based alloys). The ceramic tiles must be constrained throughout the process so that they remain in a fixed location in the part throughout the process. Also, the ceramic must not be degraded or damaged by the metal, either by chemical attack or dissolution, thermal shock damage, or residual stress induced fracture. If there is potential for reaction with the metal during the casting process, the manufacturer must detail what steps will be taken to mitigate the reaction and protect the tiles.

PHASE I: Phase I will require a manufacturer to deliver two 26” x 26” panels of a surrogate design with encapsulated unfinished 3/4" to 1" thick 4" (measured flat to flat) hexagonal ceramic tiles arranged in an A/B stacking sequence with 1/8" spacing between tiles. Tiles must be located within 1/4" and parallel to the metal surface of one side of the panel with a 1" thick cast metal backing on the opposite side of the panel. The cast metal panel side walls must be at least 1/4" thick on all sides. The process must be able to encapsulate the tiles without generating damage in the materials either by chemical attack/dissolution, thermal shock damage, or residual stress fracturing the tiles. The ceramic tiles must remain in a preferred orientation throughout the process, and the manufacturer must address how the tiles will be immobilized during the casting process. Provided by the manufacturer will be x-ray images of the encapsulation showing the location and lack of damage in the intact tiles. Further non destructive evaluation (NDE) of the panels will take place at ARL by phased array technique to verify x-ray analysis. Panels will be ballistically evaluated for qualitative analysis in this phase to inspect and verify metal-ceramic bonding. Key to potential advancement to Phase II is the ability of the manufacturer to: 1) duplicate consistent panels with required geometries and arrangement of tiles, 2) contain less than 2% porosity(by gas entrapment or internal shrinkage) without the need to hot isostatic press (HIP) the casting, 3) producing panels without weld repair and straightening, and 4) demonstrate by post ballistic analysis that the metal-ceramic interface remained intact. Ferrous amd titanium based alloys must attain a yield strength of at least 100 ksi, 10% elongation, and Charpy V-notch impact toughness of 20 ft-lbs at room temperature. Aluminum and magnesium based alloys must attain a yield strength of 40 ksi, 7% elongation, and fracture toughness of 25 ksi per root inch at room temperature. Alloy property testing must be done in accordance with ASTM standards and test data must accompany both plates and be provided to the Army Research Lab (ARL) at the time of shipment. All alloys must be gas metal arc weld (GMAW) capable. Metal matrix solutions are not sought with this solicitation.

PHASE II: Phase II will leverage existing armor designs provided by the Army Research Lab (ARL) to incorporate the manufacturing method from Phase I. The contractor will address scale-up of the process to make parts larger than the 26” x 26” size, and by the end of the Phase II be able to produce and deliver a 2 modules larger than 36” x 36”. Included in this phase is funding for non destructive evaluation (NDE) of cast material (prior to testing) as required in Phase I. Panel geometries and tile selection will be downselected to best support current Army needs at the time that Phase II is awarded. Threat specific testing will be conducted on all panels. Successful Phase II completion is predicated upon passage of the specific threat testing.

PHASE III: Successful Phase II testing facilitates immediate vehicle integration of demonstrated technology. The manufacturing technology and threat information will be transitioned to both Tank Automotive Research and Development (TARDEC) and Tank Automotive Command (TACOM) for immediate implementation and integration into existing and future platform engineering efforts.

REFERENCES:
1. ASTM E1820 (Fracture Testing of Metals), ASTM E8 (Tensile Testing of Metals), ASTM E23 (Charpy V-Notch Testing)

KEYWORDS: encapsulation, metal, alloy, ceramic, casting, ferrous, titanium, aluminum, magnesium, manufacturing cost

A10-064 TITLE: Light Weight Electric and Magnetic-Field Sensors for Unmanned Aerial Vehicles

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Develop highly sensitive passive small light weight electric-field and magnetic-field sensors for small inexpensive unmanned aerial vehicles that can be used to detect the electric and magnetic fields generated by power lines, manned aircraft, and electrical wiring in buildings.

DESCRIPTION: In order for UAVs to operate autonomously in complex environments they must have a means to sense objects in their environment. For UAVs to progress beyond mere GPS waypoint following and perform higher level near autonomous and autonomous behaviors they must have adequate information about their environment. One relatively inexpensive method to equip a UAV with the capability to sense one of the major obstacles to flight in an urban environment, power lines, is to develop electric-field and magnetic-field sensors specifically for this task. Power lines provide a particularly difficult obstacle because they require high resolution video, laser, or radar systems to detect. However, they are easily detected by well tuned electric-field and magnetic-field sensors that sense the 50 and 60 Hz frequency for common alternating current. Electric-field and magnetic-field sensors have been demonstrated with the sensitivity that would allow UAVs to have the capabilities outlined above. However, the sensors have not been demonstrated in a mode of operation in which they are being used in real-time to aid the navigation of a small flying UAV. Research will be required to design the proper sensors with appropriate fidelity and resolution. Along with the actual sensor research, there will need to be signal processing algorithm research to process the information from the electric and magnetic sensors in real-time such that the data may be used by the UAV autopilot as a navigational aid.

It should be feasible to develop highly sensitive light weight sensors with a form factor optimized for small aircraft. A multi-axis sensor suite will be required. There are examples of fairly compact single-axis electric field and magnetic field sensors. For example a single axis magnetic field sensor with 0.1 Volt/nanoTesla level sensitivity is approximately 3-6 inches in length and 0.75 inches in diameter, weighs approximately 0.2 lbs. For 3-axes the volume and weight required may be prohibitive. By employing creative packaging and innovative fabrication, it may be possible to incorporate the multiple single-axis sensors required into the airframe. There are very few integrated high-fidelity multiple-axis electric-magnetic field sensors. They are currently configured volumetrically for larger aircraft. It may be possible to reduce their size and weight for a small system, but it is likely that the airframe would require extensive modification or a new design to accommodate the relatively large sensor volume. There would also be the issue of electrical interference that comes with integration of the larger sensor.

When both electric and magnetic field sensors are employed, creative sensor fusion algorithms may allow a reduced number of sensor axes, or reduced sensitivity in an axis thus saving total sensor system weight and volume. This may be necessary for micro UAV (less than 2ft wingspan) applications where payload can be less than 0.5 lbs. An innovative approach to the actual sensor design in which the sensor was a component of the airframe would allow the sensors to serve multiple roles in the aircraft and allow high surface area for increased electromagnetic sensitivity, but minimize overall vehicle and sensor mass. The sensors could be designed as a patch, or laminate, etc and made as an integral portion of the fuselage or wing. This would give small and micro UAVs a low cost but highly effective means of sensing objects in its environment. For applications at cruise velocity which is likely to be between 45-60 feet/s for a small fixed wing UAV, high speed signal processing algorithms and hardware will be needed in order to process the multi-axis electric and magnetic sensor data in real time to use as a navigational aid. When designing the sensor system the vehicle configuration, vehicle speed, sensor range and fidelity, and hardware/algorithm signal processing speed must each be considered.

Electric and magnetic field sensors can be used to find and track power lines as well as avoid them. Another application is to use electric-field and magnetic-field sensors to allow a UAV to autonomously search for indication of hostile forces in remote regions. Hostile forces require power and the signature of its generation, transmission, and consumption can be detected. The passive nature of the sensors allow for a means to provide surveillance without giving away position. Electric-field and magnetic-field sensors may also be able to detect aircraft in flight. Thus they can be used as a means for UAVs to sense and avoid aircraft in flight, and may be an inexpensive tool for airspace deconfliction. There is also the possibility that the sensors may have the fidelity to distinguish the signatures of different aircraft. Electric-field and magnetic-field sensors could provide similar information for manned aircraft as well and could be an inexpensive means for solving such problems as power line avoidance for manned helicopters. Other uses for the electric-field and magnetic-field sensors are improvised explosive device detection and mine detection. In the future the sensors could be used to give unmanned systems the capability for autonomous power harvesting and autonomous recharging.

PHASE I: Perform a feasibility studies and/or simulations for design and effectiveness of a system (electric and magnetic field sensors, signal processing hardware, and signal processing algorithms) that is capable of geolocating man-made electric and magnetic fields in real-time on a small UAV. The system should be designed to be compatible with current U.S. Army fielded small electric powered UAV physical configurations and operational requirements such as wing span, payload weight, minimum flight speed, cruise altitude, etc. The study should provide information for feasibility of the system to carry out the following functions, 1) sense and avoid a moving or still obstacle generating an electric and magnetic field in real-time, 2) geolocate and map a non-moving electric and/or magnetic field source in real-time. The feasibility study should be of sufficient detail to assess viability of sensor concepts, signal processing algorithms, and support hardware to perform missions described above.

PHASE II: Develop and demonstrate prototype sensors on a UAV that can 1) detect and geolocate power lines and 2) detect manned aircraft in a realistic environment. Develop signal processing algorithms and associated hardware to allow detection and geolocation of electric and magnetic field sources in real-time from a small UAV. Demonstrate that the sensor autopilot/computer interface is an open architecture that can be utilized through standard autopilot/computer interfaces, (serial, TCP/IP, pulse width modulation, etc.) and gives accurate range and direction of electric and magnetic field sources.

PHASE III: The goal of this research would be to demonstrate the benefits of electric-field and magnetic-field sensors for autonomous UAV operation in complex environments. In doing so several new mission capabilities for

UAVs will be developed as well as the sensors, signal processing and control algorithms, and related hardware to perform the task. In addition, the knowledge and process for developing the sensors, algorithms, etc for this SBIR can be extended to increase UAV capability even further. The sensor materiel, manufacturing process, and vehicle integration should be relatively inexpensive. This research could be used in commercial aircraft. However it is likely that methodologies for developing the sensors for specific aircraft and missions derived from the research may be more difficult to transfer to commercial applications. The research from which the signal processing for the sensors, algorithms for autopilot interface, associated real-time signal processing hardware, etc will benefit a number applications.

REFERENCES:
1. D. M. Hull and S. J. Vinci, “Passive Aircraft Detection and Noncooperative Helicopter Identification Using Extremely Low Frequency Electric Field Sensors,” Proceedings SPIE Conference on Enforcement and Security Technologies, Vol. 3575, pp. 134 - 145, Boston, MA, November 1998.

2. H. Trinks and J. L. ter Haseborg, "Electric Field Detection and Ranging of Aircraft," IEEE Transactions on Aerospace and Electric Systems, Vol. AES-18, No. 3, pp. 268-274, May 1982.

3. P. Czipott et al., “Magnetic Detection and Tracking of Military Vehicles”, Proceedings of the MSS meeting on Battlefield Acoustic and Seismic Sensing, Magnetic and Electric Field Sensors, October, 2001.

4. Additional Q&A from TPOC in response to FAQs. (Uploaded in SITIS 06/04/10)

KEYWORDS: Unmanned aerial vehicle, power line detection, airspace command and control, electric field detection, magnetic field detection, navigation, obstacle avoidance, unmanned system

A10-065 TITLE: Probabilistic Forecasting for Aviation Decision Aid Applications

TECHNOLOGY AREAS: Air Platform, Information Systems, Battlespace

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Develop approaches and methodologies for using mesoscale ensemble modeling to produce forecast probabilities of meteorological variables critical to aviation. Establish capability to calculate forecast probabilities for meteorological parameters using ensemble model forecasts for determination of weather impacts on manned and unmanned aircraft flight routes.

DESCRIPTION: Army aviation meteorological forecasts and associated automated decision aids and assessment tools suffer from a lack of accuracy, uncertainty and reliability due to the inherent uncertainty in weather forecasts. This problem can be substantially solved by translating high-resolution, mesoscale ensemble model output to forecast probabilities for meteorological parameters along a flight path (ensemble forecasting ia a numerical prediction method used to generate a representative sample of the possible future states of a dynamical system). These forecast probabilities can then be applied to mission planning and operations risk assessment and management to increase the likelihood of mission success.

The probabilistic forecast output can be used in weighting schemes to assess the overall aviation mission risk and/or impacts due to the weather. This meteorological impact determination for aviation missions, operations and flights will advance the capabilities of the Army’s Aviation Weather Routing Tool (AWRT), the Tri-Service Integrated Weather Effects Decision Aid (T-IWEDA), and other aviation weather support tools and applications with new probabilistic presentation capabilities to enhance decision-making and course of action options. This capability will improve aviation mission effectiveness, efficiency, safety and survivability.

Ensemble model forecast probability output is required for applications of mesoscale model probabilistic forecasts of aviation impact parameters to be used for aviation route optimization, aviation mission planning and assessment of weather-related mission effectiveness and risk. Such probabilistic forecasts will revolutionize today’s deterministic forecasts by providing confidence and risk parameters as part of the forecast products. Thus, commanders will have added and focused critical weather confidence factors to aid them in battlefield decisions impacted by adverse weather conditions.

PHASE I: Determine technical feasibility and develop approaches to producing probabilistic forecasts of specific aviation weather variables such as icing, turbulence, thunderstorms, winds, and clouds from mesoscale ensemble model output for aviation meteorology. Establish a method (or methods) of calculating ensemble model forecast probabilities for aviation meteorological parameters and apply these methods to individual parameter probabilistic predictions. Develop an initial capability to take one parameter's adverse weather threshold probability of occurrence and translate that to an adverse weather impact display for a grid point, flight leg, and an entire flight route.

PHASE II: Implement the novel approach and methodology developed in Phase I to produce a prototype model and software that will output ensemble model forecast probabilities for aviation meteorological parameters at every grid point of the Weather Research and Forecasting (WRF) weather forecast model. Adapt these grid point parameter probabilities for up to five parameters at a grid point, along a flight leg, and along an entire flight path. Produce overall grid point, flight leg, and flight path weather impact calculations based on a combined probabilistic adverse weather impact calculation from these grid point probabilistic values. Develop and implement the capability to adjust weights of up to five parameters in a hierarchal scenario where one or two parameters are declared "more significant" than the others. Calculate and display overall adverse weather impact calculations based on such a weighting scheme and display these calculations at a grid point, along a flight leg, and along an entire flight path.

PHASE III: The ability to determine the accuracy and reliability of mesoscale ensemble model forecast output of aviation meteorological parameters through ensemble probabilistic forecasting is vital to improving and supporting military, civilian and commercial aviation operations and applications, and is a critical capability needed in the Distributed Common Ground Station - Army (DCGS-A) Weather Services and the Tactical Airspace Integration System (TAIS). Mesoscale meteorological ensemble model probabilistic forecasts for Army aviation support and applications would greatly benefit the Air Force, Navy, Marine Corps, civilian and commercial aviation communities. The utility of the aviation meteorological forecast probabilities would be used across the board to determine overall mission and flight impacts, effectiveness, and airspace management risk assessment for commercial, civilian, and military aircraft and aviation activities. Such calculations will benefit flight planning and mission execution aircraft routing decisions designed to help manned and unmanned aircraft avoid adverse weather conditions.

REFERENCES:
1. Eckel, F. A., Cunningham J. G., and D. E. Hetke, 2008: Weather and the calculated risk: Exploiting forecast uncertainty for Operational Risk Management. Air & Space Power Journal, 22, 71–82.

2. Grimit, E. P., and C. F. Mass, 2007: Measuring the Ensemble Spread–Error Relationship with a Probabilistic Approach: Stochastic Ensemble Results. Monthly Weather Review, 135, 203–221.

3. Eckel, F. A. and C. F. Mass, 2005: Aspects of effective mesoscale short-range ensemble forecasting. Weather Forecasting, 20, 328-350.

4. http://www.cira.colostate.edu/files/_publications_/ensemble/Zupanski_NP5.2_poster.pdf

5. Szymber, Richard J., U.S. Army Tactical Weather Support Requirements for Weather and Environmental Data Elements and Meteorological Forecasts, ARL-TR-3720, February 2006, 22 pages.

6. ARL Tri-Service Integrated Weather Effects Decision Aid (T-IWEDA) and Aviation Weather Routing Tool (AWRT), 19 pages (uploaded in SITIS 5/17/2010).

KEYWORDS: Mesoscale ensemble model, probabilistic forecasts, aviation meteorology, weather impacts

A10-066 TITLE: Neurological Simulator for Applied Data Collection

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop, build, and demonstrate an innovative, rugged, and portable head-shaped system that will simulate the properties of human brain activity as measured with standard and near-future conventional electroencephalograph (EEG) equipment.

DESCRIPTION: There is a great deal of current work in the human performance arena that centers on the application of cutting-edge neuroscience tools to real-world operational environments. This includes the integration of EEG or other measures of nervous system state with other sensor systems during specific Soldier activities. However, environmental conditions and electrical noise can adversely affect the collection of usable physiological and neurological measurements within real-world scenarios. As neuroscience experiments move from the laboratory to the field, the environment becomes less controllable by the operator, introducing novel sources of noise and error to the measuring devices. While this can be problematic, if environmental factors are known, then many sources of error can be accounted and compensated for in experimental design, recording equipment design, or artifact modeling during online and offline data analysis.

One way to tease apart externally-driven noise sources from naturally occurring and expected brain signal is through measurement of a standard or known-quantity model within the various target environments. At the moment, however, no standard model exists that can replicate human EEG-like signals within a physical structure that is similar in size, shape, and consistency of the human head. While there currently are a number of computational models outlining the conductive properties of brain matter, skull, and skin, no physical models are commercially available which also have analogous conductive properties. Likewise, the few physical, conductive models or “phantoms” discussed in academic literature or made in a handful of laboratories either have not been created in an appropriate shape for use with complete conventional EEG caps or soldier headgear; being structured as such which would enable use as a benchmark for typical off-the-shelf cap-based EEG systems.

To address this deficit, an innovative system is desired that will replicate signals analogous in size and scope to human brain activity which can in turn be measured with standard EEG equipment. In order to properly simulate the perturbation in measurement of real signals generated by human participants within varied environments, the model should be physically/conductively analogous to the human skull, scalp, and internal structure, so as to functionally replace a human during experimental setup and testing. Additionally, electrical signal generators (16-32 preferred) placed within the model should be fully programmable for future needs of generating true human EEG-like source data. Source signals may be generated or pre-programmed via an external device such as a laptop PC or signal generator for maximal flexibility.

Finally, because the model will be used as a test fixture within a wide variety of environments and varied conditions, it should be fairly durable, rugged, and portable, requiring minimal maintenance, and able to survive use within military vehicles. The end goal is to secure a device which can be used not only for examining and eliminating sources of error and noise within applied- research project environments, but also as a standard tool for comparing and validating new EEG technology and algorithms within these or other environments as it becomes available. That is, it will serve as a phantom standard for future materials testing.

This project involves research in and understanding of material science, signal generation, transmission and perturbation, and EEG equipment. Because of the wide use and popularity of EEG within the academic, industrial and medical communities, we anticipate substantial interest in such a product as both a tool in laboratory and equipment setup, and the validation and comparison of new EEG equipment, or any scenario where repeated use of live humans as a test model is either infeasible or impractical. Discussion with commercial research EEG system manufacturers has already exposed a potential market for a standard product for their own testing and development.

PHASE I: Design a concept for an innovative, rugged, and portable system that will simulate the typical voltage range of human brain activity as measured with standard and future conventional electroencephalograph (EEG) equipment. Perform an analysis of materials to be used and signal generation techniques. Show evidence of a proof-of-concept prototype.

PHASE II: Develop, build, and demonstrate an innovative, rugged, and portable system that will replicate human brain activity as measured with standard and future conventional electroencephalograph (EEG) equipment. Deliver two fully digitally controllable working models to the Army Research Lab for capability demonstration, testing, and verification.

PHASE III: Develop a marketable device which could be used in a number of applications of interest in academia, industry, and medical device development, where repeated use of human participants in neither practical nor efficient and a standard model would be preferred. This technology will be used for repetitive testing in equipment development and scenario development. The ARL and the Army Test Center could both use this device to evaluate the changing state of the art in EEG equipment, determine capabilities of current equipment and integrate developing lab techniques for operational environments.

KEYWORDS: electroencephalograph, EEG, brain, neuroscience, sensors, recording, simulation, vehicle integration

A10-067 TITLE: Programmable Multichannel RF Filter-Equalizer

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Research and develop a Programmable Multichannel Radio Frequency Filter-Equalizer having a programmable number of channels, each programmable with potentially unequal spacing, bandwidth and equalization.

DESCRIPTION: Current RF systems requiring programmable multichannel filtering resort to cumbersome implementations using parallel or switched banks of passive filters with fixed passbands and stopbands in addition to passive equalizers to tailor passband responses for each channel. Alternatives such as digital filtering implemented in Field Programmable Gate Array (FPGA) devices embedded in a system design accomplish a fixed filtering function specific to that system, limiting wider application. This topic solicits innovative proposals to research and develop a prototype Programmable Multichannel RF Filter-Equalizer with hardware and software to demonstrate the capability of a digitally programmable unit that can perform complex RF filtering functions tailored for varying signal environments encountered in multiple applications. The following goals for this topic represent technical specifications that are consonant with the applications envisioned for it. Topic proposals that are responsive to these goals and show promise of exceeding them will be given extra weight in proposal evaluation. Proposals should include material indicating investigators' knowledge of relevant technologies employed in the proposal. Proposals with exceptions to topic goals should include a rationale for doing so. The topic goals are : [1] Input signal characteristics: (a) Instantaneous operating frequency bandwidth: 200 MHz or greater with the lowest possible 3 dB passband starting at 30 MHz; (c) Input power level dynamic range: 0 to -70 dBm or wider; (d) Input impedance: 50 ohms nominal; [2] Filter response: (a) Number of channels: user programmable from 1 to 5 or more with a goal of at least 8; (b) Channel responses: nominal gain of 0 dB with user programmable center frequency, channel bandwidth, passband ripple, and arbitrary equalization capable of up to 10 dB maximum variation in each channel; (c) Stopband rejection: -70 dBc or better; (d) Channel phase response: minimum variation of group delay across the passband of each channel and across all channels; (e) Channel delay: 50 ns or less desired for each channel; [3] Operating temperature range: 0 to + 50 C; [4] Output signal characteristics: (a) Channel gain maximum variations over operating frequency and temperature ranges: +/- 0.5 dB; (b) Spurious products within instantaneous operating frequency bandwidth: -40 dBc or lower; (c) Spurious products outside instantaneous operating frequency bandwidth: -70 dBc or lower; [5] Programming: (a) Filter computation: performed by an embedded computer or (if an embedded computer is not used to do this in the system) by a host computer running a Microsoft Windows Operating System; (b) User interface: “draw your filter response” Graphical User Interface (GUI) as well as a low-level command programming syntax structured to minimize system response time to user reprogramming; (c) Filter setups: provision for saving and restoring filter setups to/from an internal non-volatile memory; (d) Interface to host computer: Ethernet 100BT; [6] Built-in test functions: user programmable, capable of assuring proper system functioning and identifying the source of major component malfunctions; [7] Operating power requirements: 115 VAC, 60Hz; [8] Input and output RF connectors: Type SMA female; [9] Physical: Single rack mountable chassis with 3U and/or 6U blades (PXI or cPCI backplanes are preferred).

PHASE I: Research, develop and propose a system design with the potential of realizing the goals in the description above, favoring proven commercial off-the-shelf (COTS) technologies to minimize technical risk. Develop technical specifications for all system components and identify them as commercially available or to be developed. Model and predict the performance of the proposed system, identifying critical components to be developed. Conduct detailed theoretical and/or laboratory investigations on the design and performance of critical components to demonstrate the feasibility and practicality of the proposed system design, including mitigation of risks associated with factors limiting system performance. Deliver a report documenting the research and development effort along with a description of the proposed system and specifications for all system components.

PHASE II: Procure or develop the system components specified in Phase I. Fabricate a prototype of the system proposed in Phase I and demonstrate its capabilities. Characterize and refine the system performance in accordance with the goals stated in the description above. Deliver the prototype system along with a report documenting the system theory, design, component specifications, performance characterization and recommendations for system performance.

PHASE III: The proposed research and development effort has wide commercial application to RF signal processing functions in military and commercial radar sensors and communication systems. Military applications include IED Defeat systems requiring complex RF filtering tailored for specific operational regions, multiband EA and EP radar and communication systems requiring strict compliance with area frequency authorizations, sonar, telemetry, Software Defined Radio (SDR), baseband communication channel selection, spectrum monitoring and surveillance. Commercial applications include telecommunications, cable TV and video, airborne and space systems, sensor signal processing, SDR and vehicular technologies. As data conversion and digital signal processing technology advances, miniaturization of this technology would enable mass production of embedded subsystems or components useable in all of these applications.

REFERENCES:
1. Wang, Yishu, "Implementation of Digital Filter by Using FPGA," Thesis, Curtin University of Technology, Bentley, 6102, Australia, June 2005. [Online]. Available: http://www.scribd.com/doc/2579002/Implementation-of-digital-filter-by-using-FPGA. [Accessed: October 15, 2009].

2. Lillington, John, "Wideband Channelization Architectures in ASICs and FPGAs," Wireless Design and Development Magazine Issue 0404. [Online]. Available: http://www.wirelessdesignmag.com/ShowPR.aspx?PUBCODE=055&ACCT=0000100&ISSUE=0404&RELTYPE=PR&Cat=0&SubCat=0&ProdCode=00000&PRODLETT=C&SearchText=wideband%20channelization&CommonCount=0. [Accessed: October 15, 2009].

3. Rajagopal, Ravikiran, "An Algebraic View of Multidimensional Multiple-Input, Multiple-Output Finite Impulse Response Equalizers," Doctoral Dissertation, The Ohio State University, 2003. [Online]. Available: http://rave.ohiolink.edu/etdc/view?acc_num=osu1070398845. [Accessed: October 15, 2009].

KEYWORDS: filter, channel, multichannel, radio frequency, RF, equalizer, digitally programmable, Improvised Explosive Device, IED, IED Defeat, Electronic Attack, EA, Electronic Protect, EP, communications, telecommunications, telemetry, radar, software defined radio, SDR, spectrum, monitoring, surveillance, data conversion

A10-068 TITLE: Low Cost Carbon Fluoride Materials for Lithium Batteries

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

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: To provide a lower cost carbon fluoride material for use on the half-5590 battery being developed for Soldier Power. This in turn will lower the cost for the finished battery.

DESCRIPTION: The Army is currently developing a battery for Soldier communication applications that utilizes the lithium-carbon monofluoride (Li-CFx) chemistry more typically used in low rate commercial applications. The cost of carbon-monofluoride (CFx) will add significantly to the total cost of the new battery, and therefore lower cost routes to these battery grade materials are sought. The phase I effort would focus on preparing carbon fluoride materials with Fluorine to Carbon ratios of 0.9 to 1.1 using new synthetic routes that can eventually result in lower cost materials. The Phase I effort should result in gram quantities of material for electrochemical evaluation by both the contractor and ARL. The phase II effort would focus on scaling up the new process and proving out the lower projected costs. Delivery of 1 kilogram quantities of carbon fluoride material would be the desired result of the Phase II. Any new material with significantly lower cost could be built into Soldier batteries using a third party. The new material would have to be proven over time to have equivalent performance to existing materials, but the lower cost would be a major factor in its eventual adoption. The development of a low cost CFx material would benefit both the Military market and the commercial sector where CFx is already used in low rate battery applications.

PHASE I: The phase I effort should focus on preparing carbon fluoride materials with F/C ratios of 0.9 to 1.1, using new synthetic routes that can eventually result in lower cost materials. The Phase I effort should result in gram quantities of material for electrochemical evaluation. New carbon fluoride materials should be evaluated in lithium cells for discharge capacity and storage performance at elevated temperature. The new materials should be compared to the standard coke based CFx materials used in commercial Li/CFx cells.

PHASE II: The phase II effort should focus on scaling up the new process and proving out the lower projected costs. Delivery of 1 kilogram quantities of carbon fluoride material would be the desired result.

PHASE III: The development of a lower cost CFx material would benefit both the Military market and the commercial sector where CFx is already used in a number of low rate battery applications such as Computer Memory and Real Time Clock Backup, Portable Instruments, Electronic Gas, Water and Electric Meters, Tire Pressure Monitoring Systems (TPMS), Toll Tags, ID Tags, Portable Electronic Devices, Cameras, Electrical locks, and Emergency signal lights.

REFERENCES:
1) T. Tan and H. Tsukamoto, "200% capacity improvement of ARMY BA5590 pack with using newly developed D-size Li/CFx batteries", Workshop on Carbon Fluorides for Lithium Batteries, Pasadena, CA, Feb. 2006.

2) J.L. Wood, A.J. Valerga, R.B. Badachhape, G.D. Parks, P. Kamarchik and J.L. Margrave, "Thermodynamic and Kinetic Data of Carbon-Fluorine Compounds", TR-ECOM-0056-F (1974); J.L. Wood, R.B. Badachhape, R.J. Lagow, J.L Margrave, "Heat of Formation of Poly (Carbon Monofluoride)", Journal of Physical Chemistry, 73 (9), 3139 (1969)

3) M.S. Whittingham, J. Electrochem. Soc., 122(4) p.526 (1975).

4) N. Watanabe, R. Hagiwara, T. Nakajima, H. Touhara, and K. Ueno, Electrochemica Acta, 27 (11) p.1615 (1982)

5) W. Rudorff and G. Rudorff, Chem. Ber., 80, 417 (1947).

6) T. Mallouk and N. Bartlett, J. Chem. Soc. Chem. Comm., 103 (1983).

7) I. Palchan, D. Davidov, and H. Selig, J. Chem. Soc. Chem Comm., 657 (1983).

8) R. Yazami and A. Hamwi, Solid State Ionics, 28-30, 1756 (1988).

9) A. Hamwi, M. Daoud and J.C. Cousseins, Synth. Met., 26, 89 (1988).

10) T. Mallouk, B.L. Hawkins, M.P. Conrad, K. Zilm, G.E. Maciel, and N. Bartlett, Phil. Trans. R. Soc. Lond. A, 314, 179 (1985).

11) R. Hagiwara, M. Lerner, and N. Bartlett, J. Chem. Soc. Chem. Comm., 573 (1989).

12) T. Nakajima, M. Koh, V. Gupta, B. Zemva, and K. Lutar, Electrochim. Acta, 45, 1655 (2000).

13) J.P. Lemmon and M.M. Lerner, Carbon, 31, 437 (1993).

KEYWORDS: carbon-fluoride, lithium battery, low-cost

A10-069 TITLE: Compact, Rugged and Ultrafast Femtosecond Laser for Hazardous Material Detection at Range

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a compact and rugged ultrafast laser system capable of advanced spectroscopic methods for detection of hazardous battlefield materials at a distance.

DESCRIPTION: Currently, the detection of hazards (e.g. explosives) at range suffer from a lack of sensitivity and selectivity due to the inability to receive signals that provide both the necessary strength and requisite information to delineate the threats from background materials. Recent research is examining advanced spectroscopy methods that utilize Quantum Control techniques as a means to overcome these shortcomings. Demonstrations have proven that detection strategies using these techniques could represent the next generation of stand-off battlefield sensors (1,2). These demonstrations are based on the ability to manipulate the inherent pulse shape of the laser excitation through frequency domain techniques. These manipulations currently rely on the bandwidth provided by large laboratory-scale Titanium-Sapphire laser sources. Development of the next-generation sensor systems requires a more compact and robust laser source not currently available. This laser source should provide ultrafast characteristics (pulsewidth less than 100 femtoseconds, optical bandwidth 10 nanometers or greater and energy/pulse greater than 100 micro-Joules) similar to laboratory system being used in sensor demonstrations. Several routes toward these specifications are potentially available (e.g. fiber laser), but many technical hurdles due to the impact from high order dispersion and gain narrowing effects have limited development to sub-picosecond pulse-width and/or few micro-joule energy levels.(3,4)

PHASE I: Develop a design for a compact, rugged ultrafast laser with high output energy in excess of 100 micro-Joules per pulse and pulse width below 100 femtoseconds equating to a bandwidth in excess of 10 nanometers assuming time-bandwidth-limited pulse properties. Predicted performance should meet optical specification mentioned for above, but also strive to design system with a volume less than 1 cubic meter in size, a weight less than 100Kg and power consumption under 600 Watts.

PHASE II: Develop, test and demonstrate a prototype laser with required specifications as mentioned in Phase I. Required Phase II deliverables will include prototype, test report and OME cost for manufacture.

PHASE III: Based on Phase II results, a minimum of two laser systems should be fabricated and characterized. These laser systems will be used to demonstrate manufacturability and to validate the fabrication process and performance. A series of demonstration tests shall be conducted to verify performances.

These laser systems can be used for multiple Military applications including: stand-off detection of chemical, biological and explosives materials being examined within Army programs [e.g. ATO R.ECB.2010.01 (Detection of Unknown Bulk Explosives)]. Commercial applications of this laser technology include analog sensing at range, but also include potential laser sources for tailored photofragmentation for Mass Spectroscopy, Laser Machining and Biomedical Engineering. The technical POCs for the phase I and II efforts will pursue further research and development funds in phase III in line with current ATO-R efforts, follow-on ATO-D and complimentary programs within the DTRA's CBRNE portfolio.

REFERENCES:

1. "Quantum Control of Tightly Competitive Product Channels," Roth, M; Guyon, L; Roslund, J, et al., PHYS.REV.LETTERS Vol. 102, 25 Art. No.253001(2009)

2. "Single-beam coherent anti-Stokes Raman scattering spectroscopy of N-2 using a shaped 7 fs laser pulse," Roy, S; Wrzesinski, P; Pestov, D, et al., APPL. PHYS. LETTERS Vol.95,7 Art. No.074102(2009)

3. "Femtosecond fiber CPA system with 325 W average power," Eidam, T.; Roser, F.; Seise, E., et al., Fiber Lasers VI: Technology, Systems, and Applications, San Jose, CA USA, Proc. of SPIE, 719514 (2009).

4. F. Roser, et al., mJ pulse energy high repetition rate fs fiber CPA system, Opt. Lett. 32, 3495 (2007).

KEYWORDS: femtosecond laser, ultrafast laser, fiber laser, quantum control, laser spectroscopy, hazardous material detection, laser amplifiers

A10-070 TITLE: Compact Light Weight Sulfur Sensor for JP-8 Fuel

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a sulfur sensor system to measure total content of sulfur in JP-8 fuel tank on combat vehicles for system control of on board fuel cell based auxiliary power unit (APU). The sensor system should be compact and light weight, and be installed either in the vicinity of fuel tank or in a suitable location between the fuel tank and the engine of the vehicle. The sulfur detection range should be from zero ppm up to 3000 ppm as specified in MIL-STD-83133F, and this system is expected to have similar degree of reliability and durability to the vehicle engine.

DESCRIPTION: A JP-8 fueled APU consisting of fuel reforming and a fuel cell is a highly desired and urgently needed technology for deployment onto combat vehicles. It is an enabling technology to ensure continued/continuous supply of electricity in critical silent mode for the duration of mission operations with additional benefit of increasing fuel efficiency and reducing logistics burden. Since the sulfur content of JP-8 fuel is detrimental to a fuel cell based APU and it varies in a wide range up to 3000 ppm, the concentration of the sulfur in the fuel must be closely monitored to allow the APU to fully function within specification. Without this information, the desulfurization system will be over designed and take up precious allocated space. A sulfur sensor would also allow for more predictable maintenance intervals, and thus a smaller overall system, by allowing the APU control system to compute when the desulfurization system needs to be cleaned or changed. Two approaches may be explored for a suitable solution, which includes innovative direct sensing of sulfur content in the liquid fuel, or indirect sensing of sulfur content after all the sulfur in the fuel is converted to SO2 gas form and subsequently detected optically/spectroscopically[1-3] at appropriate temperature. The goal of this topic is to develop a reliable, compact, and light weight SO2 sensor that is able to constantly measure the sulfur content in the JP-8 fuel in the combat vehicle fuel tank. The sulfur concentration of the incoming fuel stream, in real time, and the accumulative sulfur amount in the consumed fuel sent to the desulfurizer will be provided to the APU control system for operational parameter adjustment. Important issues such as sensor calibration, measurement interference, vibration resistance, and overall sensor system size should be considered. Using the engine exhaust as a target for measurement is allowed, but other innovative ways to convert liquid fuel to a gas mixture for better detection is encouraged.

PHASE I: Demonstrate that suitable materials, detection approach, and system design for SO2 detection. The sensor should be able to respond to SO2 at minimum 1 ppmV or below with sufficient signal strength within 30 seconds in an environment similar to automotive exhaust. Present and discuss the strategy to design the sensor that will be compact and light weight, and able to be integrated with a combat vehicle in hardware and the electronic system control of the APU with sensor fail-evident feature.

PHASE II: Design, construct, and evaluate a prototype of the complete SO2 sensor system. At the minimum, the sensor system should be demonstrated to have a lifetime of 1000 hours MTBF (Mean Time Between Failures). Deliver one complete sulfur sensor system to the Army.

PHASE III: Successful development of this sulfur sensor system for fuel cell based APU technology will enable higher fuel efficiency and less environmental footprint. This will have impact on a wide range of military power applications and will enhance the Army's fighting capability and survivability in the battlefield with reduced logistic burden and lower thermal and acoustic signatures. The technology is also applicable to commercial power and energy applications such as fuel cell based electric power generation, mobile or stationary, fueled with fossil fuels such as natural gas, gasified coal, or liquid hydrocarbons.

REFERENCES:
1. Rawlins, W.T; Hensley, J.M; Sonnenfroh, D.M. Appl. Optics 2005, 44, 6635-6643.

2. Xu, F; Zhang, Y.G; Somesfalean, G. Appl. Optics 2007, 46, 2503-2506.

3. Dooly, G; Fitzpatrick, C; Lewis, E. Energy, 2008, 33, 657-666.

KEYWORDS: Sulfur sensor, JP-8 fuel, sulfur dioxide, auxiliary power unit (APU)

A10-071 TITLE: Profile Feature Extractor (PFx) Sensor Component for Persistent ISR Applications

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a profile measurement capability that is less complex, lower weight, smaller volume, lower cost and uses less power than today's brass board profile sensors.

Each one of today's profiling sensors was developed for a specific application. Addressing the broad based applications area in this manner has resulted in a collection of brass board prototypes that are to large in volume, weigh to much, require excessive amounts of electrical power (short battery life), and cost much more than what we can afford for reasonable numbers of these sensors. In addition each brass board prototype requires an excessive amount of unique customized software to detect the object of interest, to extract the profile silhouette, and to then submit the silhouette to a standardized classifier. And today's profile sensors are also limited to monitoring a single point on the ground.

The objective is to develop a single sensor that is greatly simplified, lower cost per unit, low weight, small size, and low power (longer battery life) that meets all of the different applications including the ability to automatically extract profiles from multiple locations within a single field of view in real time. Knowing where in the field of view to extract the profiles is a major issue. Using a PDA to view the output of the profiling sensor, would allow the user to identify different locations within the image. However, using this approach requires that the user be able to see details in the scene. This approach is limited to applications with short range solutions. A more generic solution for the identification of extraction locations is required.

Another option is to use a motion detection algorithm; however, the algorithm must be able to detect object motion while ignoring the motion of other objects (grass, trees, etc). Another issue is that the detection of objects in motion does not allow one to know the specific aspect angle between the sensor and the object. Different aspect angles make the detection of back packs more difficult and also reduces the over speed of the motion through the field of view.

However, the impact on the height to width ratio of the human objects is not greatly effected by different viewing angles. And the motion detection will allow multiple silhouettes to be extracted on the same object from different aspect angles as the object moves through the sensor field of view.

It is also the objective of this innovative research task that the new profile extraction software and new classifier software must be independent of the object motion (speed) through the sensor field of view.

DESCRIPTION: The ability to automatically and reliable tell the difference between humans, animals and vehicles is a broad based operational need. What is required is a single solution that can be used in both military and commercial ISR and Security sensor systems. The commercial application will result in a low cost, low power, small volume, and low weight sensor that can be used in a wide variety of applications. And to insure interoperability across all areas the use of standard electronic interfaces and open source software is required.

The LWIR PFx component should be a passive device with an array of detectors and simple collecting optics. The detectors in the array should have a large dynamic range to provide longer range capabilities with reasonable sized optics. Range and size of the sensor translates directly into the ability to remain covert both for the installation and operation of the sensor.

To meet any one specific application, a military system integrator or commercial security system integrator, must have the capability to choose from a number of different profiling sensor capability options. Some solutions may require that the silhouette off all objects to be transmitted for viewing by an operator. Other solutions may require that a standardized classification algorithm be used to identify the silhouettes of interest and then transmit only the silhouettes of interest. This would greatly extend the battery life of the sensor system.

Another option that will be required is the ability for the integrator to quickly and easily use different types of optics for different solutions. At first glance this may appear to be simple however, the use of commercial narrow field of view optics (a COTS all reflective telescope) or a wider field of view set of optics (45 or 60 degrees) field of view with one size of detector (detector pitch) may require the inclusion of one or more interchangeable optical elements as part of the PFx component. Obviously an innovative solution is required to make these options available to the integrators, and at the same time achieve the small size, low weight, low power and low cost requirements.

Other application options may include the ability to detect the number of arms and legs, the motion dimensions (size of the arch) of the arms and legs, and the size of any backpack. In addition the PFx component may offer the option of a grayscale silhouette; however, the number of bits in the gray scale should be small.

The PFx component has a ready made commercial market in facility and home security systems. More than 99% of calls made from today’s facility and home security systems to law enforcement organizations are false alarms. Most law enforcement organizations are starting to charge a fee for responding to a false alarm. The PFx component will radically reduce the number of false alarms due to animals and electronic disturbances (lightning). Any manufacturer of facility or home security systems would gladly include a PFx as an option in their security systems.

PHASE I: Phase I will include modeling and analysis to determine the best detector size and type, and to match the detector with the optics. The optical model and analysis must address the interface of the detector array with the component optics to ensure that sufficient signal to noise is available to detect a difference or change from the background to the intensity of the pixels on the object.

Detector types that should be considered as part of the modeling and analysis include thermopile, pyroelectric, photoconductor, and micro bolometers. Both reflective and refractive optics should be considered. An all reflective solution would be preferred and would make the integration into the full up system much easier.

Digital processor considerations should include the size of the detector array the time required to process the N number of detectors that must be processed from each location within the single field of view. In addition consideration must be given to the use of grayscale silhouettes vs binary silhouettes. The intent is to transmit a minimal amount of data. Packing and transmitting binary data requires far less electrical power than the transmission of gray scale data.

Phase I should include the development of component prototype descriptions that would be used to design and fabricate prototypes during Phase II.

PHASE II: Phase II will design, fabricate, debug, test and evaluate at least one PFx component. One or more PFx components for operation in the Long Wave Infrared (LWIR) spectral region are required. Digital interfaces and data formats should follow standards and open source procedures. Software and algorithms required to extract the silhouette from the background should be looking for a difference between the object that is in motion and the background that is in a fixed position. The development of these algorithms is an important part of the solution. We do not know where the sensors will be deployed. A large majority of the time we would think of a human or animal or vehicle being hotter than the background. However, if the background is in a hot aired environment, the humans, animals, or vehicles may be colder than the background. Automatically detecting a difference between the background and the object is critical to extracting the silhouette of the object.

Deliverables at the end of Phase II will be a minimum of one LWIR low cost commercial PFx component with mechanical, optical, electronic and software documentation. The deliverables will also include the source code that runs on the profiling sensor processor card.

A written description of the alignment and calibration will be developed to insure that the component can be integrated into an ISR system and/or installed in the field correctly. It is understood that a large majority of the time, alignment, calibration and/or geo registration processes will be used in the field more than in a factory environment.

PHASE III: Phase III will include the use of the passive components in US Army Unattended Ground Sensor (UGS) systems. This could be an addition to an existing UGS system or it may be a new ISR UGS system. Commercial applications during Phase III includes the use of the PFx component in UGS systems for use on the US borders as part of the Department of Homeland Security efforts, and the PFx components would be used as part of a commercial facility security system that is sold, installed and operated by a commercial security company. In most cases, the PFx component would be used to cue other ISR sensors when humans are detected and classified.

REFERENCES:

1. Additional information and points of clarification from TPOC based on questions about Topic A10-071 received during Pre-Release. (uploaded in SITIS 5/4/10)

KEYWORDS: persistent, ISR, surveillance, wide area, profile, sensor, LWIR, algorithms, UGS, Unattended Ground Sensor

A10-072 TITLE: SOLDIER ADAPTABILITY/HUMAN DIMENSION: Knowledge Management Framework for Network Centric Operations

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop decision support system based on Knowledge Management principles, search agents and tools to reduce soldiers' cognitive workload and improve their situation awareness and mission performance during network centric operations so as to and quickly and accurately meet the Commanders Critical Information Requirements (CCIR)

DESCRIPTION: Given the shift toward network centric operations, today's battlefield has become increasingly more complex, with improved technology, larger areas of operation, and a greater number and type of incoming information. Soldiers are expected to sort through and process all of this data to determine what information is most critically needed to maintain a high level of situation awareness and support their Commander's Intent. As such, efficient knowledge management of the rich sources of data available from the network is essential for promoting timely and effective decision-making.

Knowledge management can be viewed as the art of using information to increase knowledge and is an important contributor to information superiority (Army FM 3-0). Knowledge management is aimed at capturing "lessons learned" and best practices from prior experiences of current soldiers to promote improved future warfighter performance (Battle Command Knowledge System, 2008). A key aspect of knowledge management involves information management, that is, providing the relevant information to the right person at the right time in a usable form to facilitate situation awareness and decision-making (Army FM 3-0). Information management uses information technologies to collect, process, store, display, and disseminate data from both organic (e.g., situation updates from other team members) and non-organic (e.g., various forms of sensor data) sources.

Traditional knowledge management systems consist primarily of repositories of information (e.g., databases of lessons learned and best practices). A significant challenge to successful network centric operations is to determine how to best capture the most relevant data in these databases and organize or visualize the data to meet soldiers' critical situation awareness needs in a timely manner. Knowledge assessment techniques and cognitive task analyses (e.g., Bolstad, Riley, Jones, & Endsley, 2002; Prevou & Baxter, 2008) can be used to guide the identification of the information requirements and the organization of the information for the soldier that is essential for the development and maintenance of soldiers' situation awareness and subsequent decision-making.

Our soldiers are tasked with influencing the populace and empowering the host nation to secure their own defense against insurgency efforts. MiTT commanders and their staff would greatly benefit from a knowledge management decision support system that will help them to collect, filter, and present the expansive amounts of available data in a timely manner in order to succeed in these asymmetrical warfare environments. Such data include: an understanding of the human terrain including equipment, training, culture, and operating procedures; "just-in-time" knowledge on recent insurgent activities in the area of operations; and updates from coalition partners on civilian unrest, to name but a few.

Knowledge management principles and best practices in knowledge assessment technologies can be integrated with artificial intelligence to create a decision support system that functions seamlessly with existing soldier technologies (e.g., Perusich & McNeese, 2006; Prevou & Baxter, 2008; Wang, Hjelmervik, & Bremdal, 2001). The goal is to develop a knowledge management system and corresponding software that will deliver improved information access and sharing so that warfighters can act quickly and decisively. At presents, research is needed to improve and develop sophisticated search and retrieval cap enable agents that focus on military applications to allow Soldiers and Commanders to search quicker, effectively and accurately. The tool will also improve centralized knowledge sharing services and approaches that exhibits flexibility so as to conform to different mission needs and users information priorities. Such a system can aid soldiers by reducing their cognitive workload as they search and process incoming information and, thus, would be a huge benefit to today's warfighter. In addition, a secondary benefit is that it will reduce phone and email volume which would also help reduce bandwidth in the battlefield.

PHASE I: Develop a tool based on knowledge management principles for reducing soldiers' cognitive workload in network centric environments. Design and develop an initial prototype of a system that utilizes SA oriented design, sophisticated search enable agents and knowledge management principles that improve centralized knowledge sharing services to provide soldiers with the ability to selectively attend to the information needed to maintain their situation awareness and quickly and accurately respond to information needs that support their Commander's Intent. This tool will need to demonstrate information filtering and decision support capabilities for soldiers in net centric operations,

PHASE II: Develop and demonstrate a functional prototype of the knowledge management system designed in Phase I. Conduct validation studies of the system in an operational test environment or experiments to demonstrate its utility for lowering soldiers' workload while improving situation awareness, soldier performance and demonstrate its capability to direct soldiers' attention to critical information in network centric environments. Develop guidelines and documentation for tool transition to an operational setting.

PHASE III / DUAL USE APPLICATIONS:
MILITARY APPLICATIONS: As knowledge management is critical for a wide variety of Department of Defense network centric operations, the decision support system developed through this research project will have widespread applicability to many Army and Air Force as well as Navy and Marine Corps programs. These products would be especially useful to the military intelligence community, particularly in support of Joint Forces command and control operations.

COMMERCIAL APPLICATIONS: The products developed through this research project are also valuable for commercial / private sector applications, including, for example, knowledge management in distributed multinational organizations. Non-military government applications include supporting the situation awareness and knowledge management needs of personnel in Homeland Security and border patrol operations as well as multi-agency emergency / disaster relief efforts.

REFERENCES

1. Battle Command Knowledge System (2008). Army Knowledge Management Principles. http://usacac.army.mil/cac2/BCKS/aokm2008/A4%20Doc%201%20AKM%20Principles%2025%20JUN%2020081.pdf

2. Bolstad, C. A., Riley, J. M., Jones, D. G., & Endsley, M. R. (2002). Using goal directed task analysis with Army brigade officer teams. Proceedings of the Human Factors and Ergonomics Society 46th Annual Meeting. Santa Monica, CA: HFES.

3. Perusich, K. & McNeese, M. D. (2006). Using fuzzy cognitive maps for knowledge management in a conflict environment. IEEE Transaction on Systems, Man, and Cybernetics – Part C: Applications and Reviews, 36(6), 810-821.

4. Prevou, M. & Baxter, H. C. (2008). Knowledge Assessment Tutorial. http://usacac.army.mil/cac2/BCKS/aokm2008/presentations/Tutorials/Knowledge%20Assessment%20Brief%20AOKM.pdf

5. U.S. Army (2008, February). FM 3-0 Operations. http://downloads.army.mil/fm3-0/FM3-0.pdf

6. Wang, K., Hjelmervik, O. R., & Bremdal, B. (2001). Introduction to knowledge management: Principles and practice. Trondheim, Norway: Tapir Academic Press.

KEYWORDS: Knowledge management, flexable and retrieval search agents, situation awareness, cognitive workload, knowledge assessment, network centric operations and information technology

A10-073 TITLE: Multisensory Navigation and Communications System

TECHNOLOGY AREAS: Information Systems, Human Systems

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

OBJECTIVE: Design and build a proof-of-concept system that enables investigation of multisensory navigation and communications among dismount soldiers. The system would enable dismount soldiers to quickly navigate to or away from specified waypoints or areas, while maintaining radio silence and light security. The system should utilize real-time visual and tactile cues to enable hands-free navigation and critical communications when silence must be maintained. In addition, the system will log user actions and present queries to enable detailed and automatic assessment of performance accuracy, time, and situation awareness.

DESCRIPTION: Prototypical torso-mounted tactile displays have proven effective for navigation and communication in field evaluations. These displays, if integrated with GPS, enable Soldiers to navigate at night hands-free (allowing the soldier to hold his/ her weapon) and eyes-free (allowing focused attention to surroundings as opposed to a visual display). Torso-mounted displays have also proven effective for Soldier communications, and in fact, proved better than arm & hand signals for critical communications, even during strenuous combat movements. However tactile systems must be integrated with visual and command systems to enable map-based situation awareness and easy input of waypoints. The system must be able to receive communications regarding waypoints, off-limits areas, and rally points, in real time. This system would augment battlefield visualization techniques now common to command and control, by enabling the commanders to quickly relate critical communications as to where to go or where to shoot in a manner that is immediately and intuitively understood.

The integration of a visual command center with distributed tactile communications enable dynamic battle maneuvers with intuitively understood signals. Data-logging capabilities will enable in-depth research in multisensory perception and decision making. A critical aspect of this system is its contribution as a research platform to investigate effectiveness of alternative tactile patterns and multisensory arrays. Flexible multisensory cues and data-logging capabilities will enable in-depth research in multisensory perception and decision making.

PHASE I: Research and develop an overall networked system design and a proof-of-concept prototype system that includes integrated GPS-driven tactile cues integrated with a visual map display. The proof-of concept should enable stand-alone navigation by a single person while the system design should specify the characteristics and procedures to build a networked system.

PHASE II: Develop and demonstrate a networked prototype system in a realistic environment. Conduct human interface, task cost/benefit and ergonomic evaluations across several different mission scenarios using both novice and experienced soldiers.

PHASE III: Demonstrate capabilities to military POCs. This capability can be integrated into current Soldier and command and control systems. In addition, there are many commercial applications, from enabling navigation of first-responders (firemen, rescue personnel, etc.) to activities such as hiking, skiing, or touring an unfamiliar city.

REFERENCES:
1. Duistermaat, M., Elliott, L., van Erp, J., Redden, E. (2007). Tactile land navigation of dismount soldiers. In D. de Waard, G. Hockey, P. Nickel, K. Brookhuis (Eds.) Human factors issues in complex environement performance. Europe chapter of the Human Factors and Ergonomics Society: Shaker Publishing.

2. Van Erp, J. B. F. (2002). Guidelines for the use of vibro-tactile displays in Human Computer Interaction. Proceedings of Eurohaptics 2002 (pp. 18-22). Eds. S. A. Wall, B. Riedel, Crossan, A. & McGee, M. R. Edinburgh: University of Edinburgh. 247-256.

3. Van Erp, J. B. F. (2005). Presenting directions with a vibrotactile torso display. Ergonomics, 48(3), 302-313.

4. Elliott, L.R., Duistermaat, M., Redden, E., van Erp, J., (2007). Multimodal Guidance for Land Navigation. (Technical Report No. ARL-TR-4295). Aberdeen Proving Ground: Army Research Laboratory.

5. Wickens, C. D., & Hollands, J. G. (2000). Attention, time-sharing, and workload. Chapt. 11 in Engineering Psychology and Human Performance. NY: Prentice Hall.

KEYWORDS: Land navigation; Soldier performance; multisensory display; multimodal display; command and control

A10-074 TITLE: Universal Bio-Sample Preparation Module

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: To develop a technology platform for automated, universal sample preparation for biosensor systems using small volumes of sample from complex matrices.

DESCRIPTION: Today’s warfighters face multiple threats, whether they are from an intended attack by an enemy, searching for hazardous threats or dangers which could exist in food or water supplies. There are many existing technologies and research programs on sample collection and detection; however there is a gap in developing sample preparation technologies. An ideal sample preparation scheme needs to be universal in terms of both downstream detection technology and upstream sample collection. Most biological sample preparations are labor and reagent intensive and there is a great need to miniaturize and automate this process.

Biological hazards can come in many forms including toxins, viruses, vegetative bacteria and spores. Each of these classes requires different sample processing before interrogation. Also these targets can be in complex mixtures and are frequently in matrices which are not compatible with current detection technologies. It is therefore necessary to develop the technology to remove the biological targets from the competing background matrices and to separate each class of biological target.

Combining the capabilities of target separation and clean up would provide the interface between current sample collection and detection technologies resulting in a generation of biosensors that provides real-time detection and the exact locations of threats with minimal user training and interaction, therefore reducing the strain on logistics and tactical complexity. Current needs require that these separation technologies be designed within the context of a mobile lab environment and provide targets for current and next generation analytical sensing technologies.

The module to be developed in this call must be compact and portable and be able to separate DNA, protein, protein fragments, and peptides from samples containing toxins, viruses, vegetative bacteria and spores in complex matrices such as soil, blood, and aerosol collections. Ideally, reagentless technologies are desired, however any needed reagents should be in very low volume, not target specific, and stable under field conditions. Ultimately, the sample preparation modules should be universal; that is, their utility should be compatible with the spectrum of several well-established assay technologies (e.g., molecular/immunological), as well as various transduction platforms (e.g., optical, mass, electrochemical). Processing time should be automated, less than 5 minutes and be able to separate a set of representative targets and be compatible with detection technologies to be defined prior to Phase II. Operation of the equipment shall be convenient, simple to operate, and readily accessible for Warfighters while wearing protective clothing and equipment. This solicitation seeks innovative solutions and is not intended for procurement.

PHASE I: Develop a strategy and define a prototype module for automated preparation of biological samples (against targets selected by the Army). The module will be capable of separating individual classes of biological targets (DNA, protein, virus, vegetative bacteria and spores) from a mixture in buffer. Show that the products have sufficient purity for immunoassays and that specifically, the nucleic acid products can successfully serve as PCR templates. The separation and collection of individual classes of targets should be achieved in less than 15 minutes. There should be a clear demonstration that these products are capable of functioning as targets with a well-established sensing platform. By the end of Phase I, the Technology Readiness Level should be at TRL 2-3, and the Manufacturing Technology Level should be at MRL 2-3. Phase I final report should also include both TRL and MRL assessment.

PHASE II: Further develop module from the Phase I demonstration into a test unit capable of separating the biological targets from complex matrices such as homogenized food, soil, or aqueous sample from an aerosol collector. The module will be capable of this separation within 5 minutes. The purity of these samples should be compatible for use in mass spectrometric analysis and for two or more types of sensing platforms to include optical, mass and electronic detection. Deliver an example prototype along with design plans and specifications to the Army. These specifications should place a premium on compactness, low power requirements and field durability. By the end of Phase II, the Technology Readiness Level assessment should be at TRL 4-5, and the Manufacturing Technology Level should be at MRL 3-4. Phase II final report should also include both TRL and MRL assessment.

PHASE III: Demonstrate that the module can process multiple matrices and products that can be utilized in multiple detection platforms. Military application: Sample processing and preparation for multiple detection technologies within Army programs. Applications include food and water safety, identification of infectious diseases in field environments, use in hospital, clinical or research laboratories. Commercial application: to identify infectious diseases in field environments, use in hospital clinical or research laboratories, and for civilian food and water safety. By the end of Phase III, the Technology Readiness Level assessment should be through TRL 6, and the Manufacturing Technology Level should be at MRL 5-6. Phase III reporting should also include both TRL and MRL assessment. The technical POCs for the Phase I and II efforts will pursue further research and development funds in Phase III through DTRA.

REFERENCES:

1. Microfluidic devices for sample pretreatment and applications, Chen, X. Chen, Da-Fu Cui Electrophoresis 2008, 29 (24) 4852-4861.

2. Automated sample preparation and analysis using a sequential-injection-capillary electrophoresis (SI-CE) interface. S. Kulka, Stephan, G. Quintas, B. Lendl, Analyst 2006, 131(6), 739-744.

3. Development of an Automated Sample Preparation Module for Environmental Monitoring of Biowarfare Agents. B. J. Hindson, S. B. Brown, G. D. Marshall, M. T. McBride, A. J. Makarewicz, D. M. Gutierrez, D. K. Wolcott, T.R. Metz, R. S. Madabhushi, J. M. Dzenitis, B. W. Colston, Analytical Chemistry 2004, 76(13), 3492-3497.

4. Simulation of microfluidic pumping in a genomic DNA blood-processing cassette. M. T. Taylor, P. Nguyen, J. Ching, K. E. Petersen, Journal of Micromechanics and Microengineering 2003, 13(2), 201-208.

5. A disposable DNA sample preparation microfluidic chip for nucleic acid probe assay. J. H. Kim, B. G. Kim, H. Nam, D. E. Park, K. S. Yun, J. B. Yoon, J. You, E. Yoon, IEEE International Conference on Micro Electro Mechanical Systems, Technical Digest, 15th, Las Vegas, NV, United States, Jan. 20-24, 2002, 133-136.

KEYWORDS: biotechnology, sample preparation, biosensing, hazardous materials, biomaterial sorting, toxins, bacteria, viruses

A10-075 TITLE: Widely-Tunable Distributed-feedback Mid-Infrared Laser for Standoff Chemical Detection

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a widely tunable, mid-infrared (3 to 5 µm) distributed-feedback laser for standoff detection and identification of chemical agents and toxic industrial chemicals.

DESCRIPTION: The mid-infrared (3 to 5 µm) atmospheric transmission window is important for spectroscopic application because it contains many fundamental molecular absorption features. In particular a number of toxic industrial chemicals have distinctive absorption lines in this spectral region. Infrared absorption spectroscopy has proven to be a very useful tool in the detection and identification of airborne chemicals. Pattern recognition is used to compare the infrared spectrum of library molecules against the infrared spectra of airborne contaminants. Infrared spectroscopy has been used to detect chemicals at very low concentrations. Infrared spectroscopy also holds the promise of low false alarm rates due to the spectral pattern matching over a large number of spectral bins. Standoff Infrared spectrometers have also shown promise in the area of standoff detection of liquid contaminants on manmade and natural surfaces.

Recently high-power continuous wave (CW) optically pumped distributed-feedback (DFB) lasers have become available. These new high-power CW lasers have shown promise for significantly improving current capabilities in the area of standoff chemical detection in the mid-wave infrared region. For example, power outputs as high as 11 watts in quasi-CW operation have been reported. High power output and large wavelength coverage across the infrared signature bands from 2 to 9 µm make this laser source very attractive to standoff detection programs within the Joint Service chemical and biological defense program

In a distributed feedback (DFB) laser the active region of the device is coupled to a diffraction grating in the device cladding. The grating provides optical feedback for the system during the lasing processes. Since the grating provides feedback, DFB lasers do not require discrete mirrors to form an optical cavity. Since the feedback is accomplished without mirrors, very high laser powers can be achieved. The grating can also be constructed to reflect only specific frequencies of laser light with very narrow linewidths. DFB lasers can also be configured to operate on a single longitudinal mode with very long coherence lengths, making them ideal for chemical detection techniques based on coherence. DFB lasers may provide significant advantages over current systems for the standoff detection of chemicals and chemical agents. Broadband tunability has recently been demonstrated by coupling a chirped grating with a variable optically pumped stripe region.

The goal of this program is to develop a widely tunable distributed feedback laser designed specifically for standoff detection of toxic industrial chemicals. This will require the development of a laser with wide tunability over a large wavelength range with a narrow bandwidth, while maintaining high laser power and coherence. A successful research and development effort will be expected to realize a fully operational prototype mid-infrared (3 to 5 µm) and to execute a hardware transition to some U.S. Army research laboratory or center for demonstration of capability within a military-relevant standoff detection scenario.

PHASE I: Design a distributed feedback laser based for standoff detection of a hazardous industrial chemical. The laser should operate in continuous wave (CW) mode and be rapidly tunable over a signature band of at least 100 nm within the 3 to 5 µm region. The laser should have a linewidth of less than ~ 1nm. It should have a power of at least 50 mW over the desired wavelength range. Modeling of power, tunability and coherence should be performed and performance limitations should be identified. In addition, modeling of the detection sensitivity should be performed in the context of a standoff LIDAR system that utilizes the proposed laser. Here, the system should be assessed for its ability to detect trace quantities of toxic industrial chemicals at distances of several kilometers. In particular, small hydrogen-containing compounds such as ammonia and hydrogen chloride should be used as target molecules in the simulations.

PHASE II: Fabricate a brassboard distributed feedback laser based on the design produced in the Phase I effort. Present a clear and practical analysis indicating the path from brassboard to prototype laser system that can be used in a field environment. Measure the performance of the laser and verify the performance standards established in the Phase I effort (i.e., using the same classes of toxic industrial chemicals). Plan and execute a delivery of the fully operation laser technology to some U.S. Army research laboratory or center for demonstration of capability within a military-relevant standoff detection scenario.

PHASE III: There are many defense, security and environmental relevant applications for a highly sensitive and discriminating standoff chemical detector/identifier technology. A rugged, sensitive, and flexible standoff chemical detector will also benefit the manufacturing community by providing very finely tuned monitoring of chemical processes. In addition, first responders such as Civilian Support Teams and Fire Departments have a critical need for a rugged, versatile, and rugged sensor that can be transported to the field to test for possible contamination by chemical warfare agents.

REFERENCES:
1. L. Xue, S.R.J. Brueck, and R. Kaspi, “High-Power Continuous-Wave Single-Longitudinal-Mode Operation of an Optically Pumped DFB Laser at ~ 3.64 µm”, IEEE Phontonics Technology Letters, volume 20, number 9, pages 727-729 (2008).

2. L. Xue, S. R. J. Brueck, and R. Kaspi, "Large Tunability of an Optically Pumped Mid-IR Laser with Chirped Distributed-Feedback Grating," in Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference and Photonic Applications Systems Technologies, OSA Technical Digest (CD) (Optical Society of America, 2008), paper CTuZ5. (2008)

3. C. S. Kim, M.Kim, W. W. Bewley, C. L. Canedy, J. R. Lindle, I.Vurgaftman, and J. R. Meyer, “High-Power Single-Mode Distributed-Feedback Interband Cascade Lasers for the Midwave-Infrared”, IEEE Photonics Technology Letters, Volume 19, Issue 3, pages 158-160 (2007)

4. R.Q. Yang, C.J. Hill, K. Mansour, Qiu Yueming, A. Soibel, R.E. Muller, and P.M Echternach,.”Distributed Feedback Mid-IR Interband Cascade Lasers at Thermoelectric Cooler Temperatures”, IEEE Journal of Selected Topics in Quantum Electronics, Volume 13, Issue 5, Part 1, pages 1074-1078 (2007)

5. J. S. Yu, S. Slivken, S. R. Darvish, A. Evans, B. Gokden, and M. Razeghi, “High-power, room-temperature, and continuous-wave operation of distributed-feedback quantum-cascade lasers at ~ 4.8 µm”, Applied Physics Letters, Volume 87, Issue 4, page 041104 (2005)

KEYWORDS: Chemical Detection, tunable laser, Distributed Feedback Laser, Infrared spectrum, manufacturing materials and processes, A10-076 TITLE: Terahertz Emitter Based on Frequency Mixing in Microchip Solid-State Laser Cavity

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

OBJECTIVE: To develop and demonstrate a compact, portable, widely-tunable, and narrowband terahertz (THz) emitter, based on frequency mixing of two lasing beams in a nonlinear crystal being placed inside a dual-frequency solid-state laser cavity.

DESCRIPTION: THz spectroscopy holds promise in the identifications and detections of biological and chemical species [1]. However, such applications have been impeded primarily by the lack of a miniature, portable, coherent, high-power, and widely-tunable THz source [2-5]. It was demonstrated in the past that among all the schemes for THz generation, frequency mixing of two laser beams in a nonlinear crystal can be quite efficient [6]. However, since the lasers emitting the two frequencies are bulky, the corresponding THz source is not portable. Recently, a single-mode ultra-compact Nd:YAG microchip laser has produced ultra-high peak powers [7]. However, since a Nd:YAG laser has a rather narrow lasing bandwidth, it cannot be used to produce two different frequencies necessary for the generation of THz waves in a nonlinear crystal. Other solid-state lasers such as those based on a Nd:LSB laser crystal can generate lasing frequencies tunable within a broad frequency range [8-9]. Recently, a CW dual-frequency Nd:LSB microchip laser was implemented and used to generate THz waves [10]. In order to significantly scale up THz output powers, nanosecond laser pulses should be used. In addition, frequency mixing inside a dual-frequency solid-state laser cavity (i.e. intracavity frequency mixing) can dramatically improve the THz output powers. Since the THz output peak power based on frequency mixing is proportional to the product of the input peak powers for the two mixing beams, nanosecond laser pulses and intracavity frequency mixing can be employed to increase the THz output peak powers by four orders of magnitude. As a result, the average THz output powers are expected to approach the mW level. Moreover, novel structures such as plasmonic metallic gratings [11] and stacks [12] can be incorporated to modify dispersion of a nonlinear crystal, spatially confine THz waves, and utilize quasi-phase-matching, and therefore, to further improve the conversion efficiency for the THz generation. Therefore, a research and development effort is expected that will utilize nonlinear mixing and a dual-frequency solid-state cavity to demonstrate significantly enhanced THz emission performance and to demonstrate the effectiveness of the source technology within a military-relevant sensing and/or monitoring application.

PHASE I: In Phase I, laser devices should designed, fabricated, and tested that are capable of CW dual-frequency and transform-limited Q-switched dual-frequency operation. Here, laser technologies should be investigated that are amenable to significantly up scaling the output power at terahertz frequencies. Note that lasers based upon Nd:LSB crystals are one potential candidate but other alternatives that offer the same or superior performance are acceptable. Detailed feasibility studies on intracavity THz generation based on the performances of the CW and Q-switched laser technologies investigated above should be executed and the results should be used to construct a development plan for a military-relevant sensors demonstration.

PHASE II: In Phase II, the methodology of THz generation inside the cavities of both CW and Q-switched dual-frequency lasers should be achieved, followed by the characterization and optimization of the THz emitter. Novel configurations and structures for achieving THz generation and enhancement such as total internal reflection, non-collinear propagation, backward propagation, plasmonic metallic gratings, and cavity should be investigated. By the end of Phase II, the first-generation electrically-driven miniature and monolithic THz emitter operating at room temperature should be demonstrated that achieve (or closely approach) the following operational capabilities: an average output power of 1 mW, a peak output power of 20 W; a continuously frequency-tuning range of 150 GHz – 1 THz (5-33.3 cm-1); a linewidth of 100 MHz; a repetition rate of 10 kHz; and, a system dimensional footprint of 10"×6"×4" or smaller. The Phase II effort should also include a sensing/monitoring demonstration that illustrates the advantages of the technology for a military-relevant application, and the preference is for this activity to be connected to a U.S. Army research laboratory or center.

PHASE III: The resulting THz source technology for be useful in the development of compact THz sensor systems for such military and private sector applications as sensing and monitoring of biological species, explosives, and hazardous chemicals as well as for nondestructive evaluation and medical diagnostics. The proposed technology development would also find dual-use applications in other highly specialized areas such as providing for ultra wideband communication capabilities for short-range, covert and/or space-based communications, and providing components for ultra fast/high-frequency data processing and computation.

REFERENCES:
1. T. R. Globus, et. al., “THz-spectroscopy of biological molecules,” J. Biol. Phys. 29, 89-100 (2003); A. Bykhovski, et. al., “An analysis of the THz frequency signatures in the cellular components of biological agents,” Intern. J. High Speed Electron. Sys. 17, 225-237 (2007).

2. C. Walther, M. Fischer, G. Scalari, R. Terazzi, N. Hoyler, and J. Faist, “Quantum cascade lasers operating from 1.2 to 1.6 THz,” Appl. Phys. Lett. 91, 131122/1-3 (2007).

3. T. J. Edwards, D. Walsh, M. B. Spurr, C. F. Rae, M. M. Dunn, and P. G. Browne, “Compact source of continuously and widely-tunable terahertz radiation,” Opt. Exp. 14, 1582-1589 (2006).

4. K. Kawase, M. Sato, T. Taniuchi, and H. Ito, “Coherent tunable THz-wave generation from LiNbO3 with monolithic grating coupler,” Appl. Phys. Lett. 68, 2483-2485 (1996).

5. K. Kawase, J. Shikata, and H. Ito, “Terahertz wave parametric source,” J. Phys. D: Appl. Phys. 35, R1-R14 (2002).

6. W. Shi and Y. J. Ding, “Tunable terahertz waves generated by mixing two copropagating infrared beams in GaP,” Opt. Lett. 30, 1030-1032 (2005).

7. H. Sakai, H. Kan, and T. Taira, “>1MW peak power single-mode high-brightness passively Q-switched Nd3+:YAG microchip laser,” Opt. Exp. 16, 19891-19899 (2008).

8. W. K. Jang, T. Taira, Y. Sato, and Y. M. Yu, “Laser emission under 4F5/2 and 4F3/2 pumping in Nd:LSB micro-laser,” Jap. J. Appl. Phys. 43, L70-L72 (2004).

9. S. V. Voitikov, A. A. Demidovich, L. E. Batay,A. N. Kuzmin, and M. B. Danailov, “Sub-nanosecond pulse dynamics of Nd:LSB microchip laser passively Q-switched by Cr:YAG saturable absorber,” Opt. Commun. 251, 154-164 (2005).

10. U. Willer, R. Wilk, W. Schippers, S. Böttger, D. Nodop, T. Schossig, W. Schade, M . Mikulics, M. Koch, M. Walther, H. Niemann, and B. Güttler, “A novel THz source based on a two-color Nd:LSB microchip-laser and a LT-GaAsSb photomixer,” Appl. Phys. B 87, 13-16 (2007).

11. Q. Gan, Z. Fu, Y. J. Ding, and F. J. Bartoli, “Ultra-wideband slow light system based on THz plasmonic graded metallic grating structures,” Phys. Rev. Lett. 100, 256803/1-4 (2008).

12. Y. Jiang, Y. J. Ding, and I. B. Zotova, “Power scaling of coherent terahertz pulses by stacking GaAs wafers,” Appl. Phys. Lett. 93, 241102/1-3 (2008).

KEYWORDS: Terahertz, Nd:LSB laser, dual-frequency laser, intracavity, frequency mixing, spectroscopy, biological, chemical, explosive, nondestructive evaluation, medical diagnostics, manufacturing materials

A10-077 TITLE: Energy-Dense Hydrocarbons from Eukaryotic Microorganisms

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop eukaryotic microorganisms for the production of energy-dense alcohols or hydrocarbons with a carbon number of four or greater via fermentation using existing commercial infrastructure.

DESCRIPTION: The development of alternative sustainable fuels is essential to maintain Army capabilities in the face of dwindling fossil fuel stores. Biofuels, derived from renewable biological sources, are an attractive option to fulfill this need. Such fuels could be used directly for soldier-borne power capabilities or could be converted into JP-8 for a sustainable source of logistics fuel. Ethanol has served as the first model for a commercial biofuel, but several limitations prevent widespread use, including limited energy density, incompatibility with the existing pipeline infrastructure, and the requirement to process food crops for fuel production. Therefore, recent efforts have focused on the production of more complex (C4 or greater) energy-dense hydrocarbons derived from non-food crops. Such higher chain molecules possess superior properties relative to ethanol, including increased energy density, low water absorption, low vapor pressure, and low corrosiveness. Moreover, these properties approach the capability of transporting such fuels through existing pipeline infrastructure. Energy-dense hydrocarbons can be blended with gasoline and even have the potential to be used as fuel replacements (e.g., butanol performs well in conventional gasoline engines).

The primary route for production of sustainable energy-dense hydrocarbons is the conversion of biological material by microorganisms. Genetically engineered bacteria have been developed that produce a variety of compounds including higher chain alcohols and hydrocarbons. However, the commercialization of fermentation processes that rely on bacterial microorganisms is hampered by low robustness to process conditions and incompatibility with existing infrastructure. In contrast, commercial fermentation processes utilizing eukaryotic microorganisms have already been established for various products, including ethanol and lactic acid, but not for higher chain alcohols or hydrocarbons. The goal of this topic is to develop eukaryotic microorganisms (single species monoculture or a microbial consortium) for production of energy-dense alcohols or hydrocarbons with a carbon number of four or greater via fermentation using existing commercial infrastructure.

PHASE I: Develop approaches for engineering eukaryotic microorganism(s) to produce energy-dense hydrocarbons in a commercially viable yield. The hydrocarbons produced must exhibit minimal water absorption, low vapor pressure, and low corrosiveness.

PHASE II: Integrate the eukaryotic microorganism(s) into commercial fermentation apparatus, demonstrate production of a minimum of 5 gallons of energy-dense alcohol or hydrocarbon for testing and analysis, and optimize yield.

PHASE III: The development of a system to produce energy-dense hydrocarbons using existing commercial fermentation apparatus will support capabilities for soldier-borne power systems driven by sustainable fuels. In addition, this system will provide a sustainable source of hydrocarbons for conversion to JP-8 in support of Army logistics. Commercial applications will have a significant positive impact on civilian life and the environment. A sustainable supply of fuel will reduce dependence on foreign oil supplies, increasing national energy security. Fuel that is less costly and clean-burning will enable enhanced civilian capabilities and reduce greenhouse gas emissions.

REFERENCES:

1. Connor, M.R. and Liao, J.C. Microbial production of advanced transportation fuels in nonnatural hosts. Current Opinion in Biotechnology, v.20, p.307–315, 2009.

2. Alper, H. and Stephanopoulos, G. Engineering for biofuels: exploiting innate microbial capacity or importing biosynthetic potential? Nature Reviews Microbiology, v.7, p.715-723, 2009.

3. Brenner, K., You, L., and Arnold, F.H. Engineering microbial consortia: a new frontier in synthetic biology. Trends in Biotechnology, v.26, p.483-489, 2008.

4. Steen, E.J., Chan, R., Prasad, N., Myers, S., Petzold, C.J., Redding, A., Ouellet, M., and Keasling, J.D. Metabolic engineering of Saccharomyces cerevisiae for the production of n-butanol. Microbial Cell Factories, v.7, 2008. http://www.microbialcellfactories.com/content/7/1/36

5. Fortman, J.L., Chhabra, S., Mukhopadhyay, A., Chou, H., Lee, T.S., Steen, E., and Keasling, J.D. Biofuel alternatives to ethanol: pumping the microbial well. Trends in Biotechnology, v.26, p.375-381, 2008.

KEYWORDS: eukaryotic microorganisms, fermentation, hydrocarbons, alcohols, biofuel

A10-078 TITLE: Compact, High Intensity, Low Cost, Free Standing Illumination Sources

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The objective is to develop an innovative concept of an illumination system providing extremely high level of illumination of 200,000 lumens/sq meter for ultra-fast photography (million frames/sec or more) of dynamical events such as IED blasts or RPG impact on Army platforms and implement the concept into a prototype.

DESCRIPTION: The Army needs high power light sources for high speed photography. The cameras with frame rates of million frames/sec or higher frame rates are increasingly being used for recording of fast events such as impact of a projectile on Army platforms such as tanks and APCs or an IED blast. To image fast events from a distance of 50 to 100 meters, high power collimated illumination sources are needed. This is because of the fact that with higher frame rates the number of available photons decrease proportionately, i.e. the number of available photons per pixel per frame for million frames per second will be approximately 33,000 times lower than 30 frames per second rate. We require illumination sources capable of delivering an illumination intensity of 50-200,000 lumens over one to several square meters of area for a number of applications. Higher intensity illuminators may be required in future so the solution should be scalable for higher illumination.

Current state of the Art: The current technology for such illuminators are plasma light sources which are commonly used for stadium lighting, which ganged together can deliver up to 20,000 lumens. The size should also be no more than 65 cubic inches. However they cannot be focused into narrow divergence to deliver high illumination intensity at a distance of a hundred meter required for our application. Improved plasma sources or other technologies such as LEDs and lasers can be considered for the approach. The sources should be low maintenance and rugged to be deployable in the field. The wavelength of the sources should be compatible with silicon CMOS or CCD imagers. The illuminator should be operable from line power or vehicle power. The size of the unit should not exceed 12x12x8" and the weight should not exceed 25 lbs. They should also be low cost, easy to use and easy to repair and replace its components.

PHASE I: In phase I, the objectives are 1) to study the need for a compact, high intensity, low cost, free- standing illumination source and 2) to develop a proposal to address it. A convincing argument should be made through theoretical or experimental studies that the solution would be able to address all the aspects of the problem. A proposed design of the illuminator should be made in phase I. The contractor should understand environmental and safety concerns and propose methods to address such concerns. The contractor should define metrics that will be used to in phase II to monitor the progress of the project. The deliverables of phase I will be the design and documentation around the illuminator which would be built in phase II.

PHASE II: In phase II, the contractor will build two prototype illuminators. A design review will be held before starting the build. The illuminator prototypes will be thoroughly characterized in the contractor's laboratory. The deliverables will be 1) the two illuminators for further testing, and 2) documentation of the test results that obtained at the contractor's site.

PHASE III: Successful completion of phase III will demonstrate qualified devices which can built for multiple applications. A variation of the design which would be useful for commercial and industrial applications must be demonstrated. Commercial applications could include ultra-fast photography of various industrial accident scenarios, automobile and airplane crash events, and fast chemical reactions in chemical plants and in laboratories. A TRL (Technology Readiness Level) of 7 must be met by the devices. The contractor should demonstrate the ability to produce significant quantities of the hardware in phase III.

REFERENCES:

1. Thuvan Piehler, Barrie Homan, Rachel Ehlers, Richard Lottero, and Kevin McNesby, ARL-RP-137, High Speed Laser Imaging, Emission and Temperature Measurements of Explosions, Insensitive Munitions & Energetic Materials Technology Symposium Proceedings, Bristol, UK, April 2006.

2. Peter Nebolsine, Christopher Rollins, and Edmond Lo, Physical Sciences, Inc., Final Report Subcontract No. FMD 9401, High-Frame Rate Data Collection for Advanced Armor Instrumentation Enhanced Imagery, October 1994.

3. B.W. Baum, L.L. Shaw, S.C. Simonson, and K.A. Winer, Linear Collapse and Early Jet Formation in a Shaped Charge, Proceedings of the 14th International Symposium on Ballistics 1993, Vol. 2, p. 13-22, 1993.

4. M. R. Krames, O. B. Shchekin, R. Mueller-Mach, G. O. Mueller, L. Zhou, G. Harbers, and M. G. Craford," Status and Future of High-Power Light-Emitting Diodes for Solid-State Lighting," J. Display Technol. 3, 160-175 (2007)

5. R. Hülsewede, H. Schulze, J. Sebastian, D. Schröder, J. Meusel, and P. Hennig, High brilliance and high efficiency: optimized high power diode laser bars; Proc. SPIE, Vol. 6876, 68760F (2008);

6. Doron Nakar, Asher Malul, Daniel Feuermann, and Jeffrey M. Gordon, Radiometric characterization of ultrahigh radiance xenon short-arc discharge lamps, Appl. Opt. 47, 224-229 (2008)

KEYWORDS: Vertical Cavity Surface Emitting Laser (VCSEL), compact illuminators, self-contained, high-luminosity, high-speed video, plasma lights, laser illumination, arc discharge lamp, ruggedized illuminator, MRAP

A10-079 TITLE: Smart Body Armor Active Protection System

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: This work is aimed at designing body armor which will detect the direction of azimuth of an incoming/impinging impact and activate a system to block, attenuate, and diffuse shock wave induced kinetic energy, thereby preventing transfer of net momenta to sensitive body organs and to the epidermal regions in line with these organs.

DESCRIPTION: This work is aimed at designing body armor which will detect the direction of azimuth of incoming/impinging impact using sensors which will active the directed release of a material from nearby reservoirs to an interior position so as to block, attenuate, and diffuse shock wave induced kinetic energy, thereby preventing transfer of net momenta to sensitive body organs and to the epidermal regions in line with these organs. This cushioning and critical damping intervening action (akin to a series of mini-airbags) will prevent damage by shock waves to the hydrogen-bonding network of epidermal tissue -- this bonding being extremely weak and short-lived, and having thus the requirement for fast re-construction without permanent damage. The water molecules that sheath the phosopholipid bi-layer (hydrophyllic extremities of fatty acids) undergo a transition in response to perturbation-induced impact, and this post impact state has properties more akin to those of ice, rather than those of liquid H2O. The net result is that the impact conveys the properties of a rigid bar collision rather than a collision with a liquid state of matter. The collision effect can also generate a tautomeric transition in bio-molecules that associate with water, such as the nucleic acid adenine, and this can lead to genetic defects if cells are adversely affected by the impact and net momenta transfer. The enhanced nano-ordering occurs very rapidly, in millisecond time-frame.

The possible long-term effects of small-arms induced shock wave impact to epidermal layers of the skin can ultimately become cancerous lesions, and if not treated sufficiently early, can lead to death of cells due to erratic proliferation. The probability for death will be accelerated if excess Ca^{2+} ions associate with the damaged cells . The dynamic action response zones of the smart body-armor will concentrate on protecting the heart, liver, and small intestine of the person wearing the armor. In this work, a coupling of a very fast switching material must be employed, in conjuction with a fast-jet system so as to very quickly interrupt/interdict the shock wave that is produced by the small arms impact.

The decision to execute this protection-enhancing deployment system, and its actual execution and functioning, must occur in a very short period of time. The decision to initiate air bag deployment is currently made in a time period of 15-30 milliseconds, and the air bag is fully deployed within 60-80 milliseconds after the onset of a crash impact. Comparatively, the body armor smart-response must be executed in a shorter time interval to prevent penetration of a round, and to significantly attenuate the leading edge of a shock wave.

Considering the average velocity of sound is 3000 m/sec in the combination of void-air-space and fabric in the smart body-armor, a sound wave would travel 300 cm in 1 millisecond. Thus a response time in the microsecond range would be favored to interrupt and attenuate a shock wave, especially the leading edge. This requires a very fast switching-triggering system to be employed in the smart armor design (2).

The switching-triggering strategy would be to cascade sensing, switching, and actuator devices so that the leading edge of the impact sensor output signal would serve as the input of a very fast switching device. The consequent output signal would serve to trigger the actuator/generator device that releases the directed mass through the conduit system to the appropriate circular disk vulnerability region where the input has occurred or will imminently occur.

PHASE I: TRL 2-3 Phase I includes characterization of subsystems, materials, and functionality of the proposed body armor system. This shall include characterization of inhomgeneity and non-isotropicity of fabrics and armor plates, impact and/or bow wave detectors and determination of the optimal sensor system. Fast switch coupling will then be delineated. Interdicting materials research will focus on fast response mass-transfer interdicting materials. Finally, the propelling system of interdicting material will be specified. At the conclusion of Phase I, a design review will be conducted.
Deliverable: Written report detailing all work perfromed, along with Phase II plan.

PHASE II: TRL3-4 Phase II involves design of the optimal integration of all the sub-systems into the smart body-armor, allowing the system to be bread-boarded and subsequently brass-boarded- including the development of counter-countermeasures, if deemed appropriate, after studying effectiveness of enemy attempts at the neutralizing of the intelligence of the body armor. Individual elements for the body armor system resulting from the Phase I design review will be tested and integrated into a working prototype to be tested in a relevant environment.
Deliverable: Full report including design review, test results, and demonstration of working prototype.

PHASE III: TRL 4-6 Ultimate Specific Military and Commercial Applications: The military application is to protect first-wave combat Army infantry troops, and marines, as well as to protect counter-insurgent and security personnel, and helicopter pilots. The commercial applications are to protect police personnel, especially SWAT teams from fire from perpetrators, FBI teams, and other specialized units. The Phase II prototype will be refined for brassboard testing and commercialization.
Deliverable: Full report, along with all test results and demonstration of brassboard vehicle in a relevant environment.

REFERENCES:

1. G. C. Vezzoli, "Increase in nano-order of liquid H2O(induced by chemical, charge, and mechanical stimuli: relationship to water-DNA system", Mat. Res. Innov. 11(2), 95-105 (2007)

2. T. Boudou, J. Ohayon, C. Picart, R. Pettigrew, P. Tracqui, "Nonlinear elastic properties of polyacrylamide gels: Implications for quantification of cellular forces", Biorheology 46(3), 191-205, 2009.

KEYWORDS: body armor, high speed air bags, soldier protection, fast switching materials, biolethality, body armor materials, protective armor, smart body armor, active protection body armor

A10-080 TITLE: <u>FORMULATION AND PRODUCTION OF NOVEL BARRIER MATERIALS</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, 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: This SBIR topic calls for the development of semi-permeable and permselective membranes to serve as quality control standards in traditional Individual Protective Equipment (IPE) and Collective Protection (ColPro) swatch testing. Furthermore, innovative technology to reproducibly and repetitively fabricate these membranes is required. The IPE and ColPro barrier materials protect the warfighters, first responders, etc. from chemical and biological agents. To effectively determine the protective capabilities of these barrier materials, they must be tested against the chemical and biological agents. The proposed semi-permeable and permselective membranes shall serve as quality control standards in the testing regimen.

DESCRIPTION: The modern warfighter depends on individual protective equipment (IPE) and Collective Protection (ColPro) equipment as chemical and biological shields. Prior to fielding, IPE and CoLPro equipment typically undergo extremely involved processes that can require many years of testing and evaluation. Over the years numerous test methods have emerged and various fixture designs have developed to accommodate testing programs in the continuing effort to protect those who protect us. Present analytical methodologies used in evaluation of Individual Protective Equipment (IPE), and Collective Protection (ColPro) barrier materials lack a comprehensive quality control reference standard. Standard material candidates are needed to enhance the quality of testing conducted under TOP 8-2-501. Currently commercial off the shelf (COTS) fabrics and polymeric materials are utilized as standards. These materials are less than ideal mainly because of the lack of conformity in their production processes. Past attempts at identifying other COTS materials have been less that successful. An innovative manufacturing process might be the most direct route to acquiring a more effective, practical standard material. Membrane development research is a very active field of endeavor in science and technology. It would be very advantageous to the military testing community to enlist the talents of such experts in the development of novel materials. Incorporating superior reference materials that deliver highly precise and accurate results in barrier materials testing will strengthen the quality of the testing by generating control data at a level that is not currently available.

PHASE I: Phase I will demonstrate scientific, technical, and commercial merit and feasibility of the production concept. The chemical structure and composition of each proposed reference material will be identified. A comprehensive, nondestructive testing protocol for establishing uniformity throughout the lot of material or among the individual swatches is required.

PHASE II: The production concept and design and testing procedure from Phase I shall be finalized. Develop and construct innovative prototype production process and demonstrate and validate it. Provide sufficient samples of each proposed swatch material with uniform test results to establish successful development of process. Perform and submit time, labor, and cost feasibility study. Pursue patents on all novel test materials and processes that are developed and refined under the Phase II work effort.

PHASE III: During Phase III, develop extended commercial applications for the novel test materials and applicable test systems. Areas of applicability for novel semipermeable and permselective membranes may include food packaging, textile manufacturing, and medical applications. In Phase III, obtain funding from non-SBIR government sources and/or the private sector to develop or transition the prototype into a viable product or service for sale in the military or private sector markets.

REFERENCES:
1. Kim M.J. et al, “Gas Permeation Through Water-Swollen Polysaccharide/Poly(vinyl alcohol) Membranes”, Journal of Applied Polymer Science, 2004, Vol 91, 3225

2. Alvarez V.A. et al, “Non isothermal Crystallization of Polyvinylalcohol-co-ethylene”, Journal of Thermal Analysis and Calorimetry, 2005, Vol 79, 187

3. Alvarez V.A. et al, “Isothermal Crystallization of Poly(vinyl-alcohol-co-ethylene)”, Journal of Applied Polymer Science, 2003, Vol 89, 1071

4. Dai, Y. et al, “Novel Polymers with Pendant Hexafluoroisopropanol Groups for Gas Separation Membrane Materials”, Macromolecules, 2005, Vol38, 9670

5. Xiao Y. et al, “Effects of Brominating Matrimid Polyimide on the Physical and Gas Transport Properties of Carbon Membranes”, Macromolecules, 2005, Vol38, 10042

KEYWORDS: Chemical / Biological agents, standard, material standard, standard reference material, Individual Protective Equipment (IPE), Collective Protection (ColPro), barrier materials, test and evaluation, semi-permeable, permselective, membranes, quality control standards, swatch testing, Air Vapor Liquid Assessment Group (AVLAG)

A10-081 TITLE: Novel Passive Low Light Level Solid State Imager Development

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop and demonstrate a solid state photodetector technology that exhibits passive low light level performance equal to or exceeding that of current Gen III image intensifiers. The goal is to develop a low cost, small in size and weight, low power, man-portable, solid state imager as a video based sensor technology alternative to the current image intensifier tube based imagers. The imager is to operate at 30Hz frame rate minimum (60Hz frame rate desired), with no or minimum cooling required and demonstrates low light level (overcast starlight) performance.

DESCRIPTION: Current image intensifier (I2) goggle technology for man-portable applications is bulky in size and weight and does not lend itself to be fused with other solid state sensors such as shortwave infrared (SWIR), midwave infrared (MWIR) and/or longwave infrared (LWIR). Conventional silicon Charge Coupled Devices (CCDs) and Complementary Metal Oxide Semiconductor (CMOS) imagers are incapable of passive low light level performance due to high dark current and high readout noise limitations. For passive low light level imaging, the signal must be maximized and noise minimized. CCDs for astronomy applications have been shown to have low light level performance capability by cooling to reduce dark current and by operating at a much slower frame rate which effectively maximize the integration time and reduce the readout noise. Recent impact ionization CCD developments potentially could provide low light level performance at normal video frame rates however it is unclear if this technology is suitable for man-portable applications due to the cooling requirement to reduce dark current and sustain sufficient gain. This topic seeks to develop a low cost, low power, uncooled or minimally cooled, man-portable solid state sensor operating at normal video rates to replace the current I2 goggle technology. To achieve performance comparable to Gen III I2 goggle technology, the solid state technology must exhibit high gain with low excess noise, high quantum efficiency and low dark current at ambient temperature. The technology must show a clear path to a compact, low power, small pixel pitch, high resolution imager. The target imaging sensor should be of 1280 x 1024 SVGA format (minimum) or HDTV 1920 x 1080 (desired), 12 um pitch or less, 30 Hz (minimum) or 60Hz (desired) operation, with 40 degree field of view optics.

PHASE I: Demonstrate the technical feasibility of the proposed approaches through design and analysis. The proposed design shall be optimized for low dark current, low read noise, large dynamic range and linearity, low power, and high sensitivity. Test circuits or small format arrays to demonstrate the design concepts are highly desirable in the Phase I effort.

PHASE II: Using the results of Phase I effort, build, demonstrate and deliver a man-portable solid state imager/camera system with passive low light level performance that is comparable or exceeds the current Gen III I2 goggle technology. Demonstrate a clear path to low cost production.

PHASE III: The commercialization of this technology is expected to provide low cost, high performance low light level imagers for potential uses in a 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.

REFERENCES:
1. P. Jerram, P. J. Pool, R. Bell, D. J. Burt, S. Bowring, S. Spencer, M. Hazelwood, I. Moody, N. Catlett, and P. S. Heyes, “The LLCCD: low-light imaging without the need for an intensifier”, in Proc. SPIE, 4306, pp. 178-186, May 2001.

2. D.Rathman, K. Pedrotti, S. Gaalema, et. al., “Hybrid Low-Light–Level CMOS Sensor Development”, in Proc. SPIE, 1998.

KEYWORDS: low light level, near infrared, NIR, shortwave infrared, SWIR, night vision

A10-082 TITLE: Active Closed Loop Infrared Countermeasures (CLIRCM) Sensor for Rotary Wing Aircraft

TECHNOLOGY AREAS: Air Platform, 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 next-generation sensor technology for active Closed Loop Infrared Countermeasure (CLIRCM) of Missile Seeker threats to US Army rotary wing platforms.

DESCRIPTION: Current IR Missile Warning Sensors for helicopters are based on passive plume detection using either UV or IR. These sensors are subject to false alarms from non-threat optical sources. Additionally, when these sensors are used in conjunction with a laser-based seeker jamming system, there is a significant level of hand-off error and time delay associated with the sensor cuing the tracker and the tracker locking onto the incoming missile. The utilization of a laser-based optical augmentation (OA) sensing technique (hence the term 'closed loop'), coupled with the same laser countermeasure system jamming the incoming threat missile, to identify the specific threat for jam code selection precision and to provide real-time feedback on jammer effectiveness, could significantly reduce the level of false alarms as well as the time to detect and jam the missile. In addition to improved performance, coupling multiple functions into the pointer tracker head will reduce the size, weight and cost associated with this capability.

The use of OA to locate/track/interrogate an incoming missile is possible due to the significant technical progress made in high-power, high Pulse Rate Frequency (PRF) Mid Wave Infrared (MWIR) laser sources and next generation pointer-trackers. This effort will investigate the use of OA as a closed loop seeker interrogation technique to improve jammer effectiveness by providing the capability to identify specific threat types and jam code effectiveness in real-time. The goal of this topic is to develop OA closed loop detection/track/interrogation techniques for eventual use to improve the performance of jammers on rotary platforms.

Top-level requirements for this sensor system are: 1) demonstration of OA closed loop technique for missile detection at tactically useful ranges 2) Detection Range of threats at > 4 km 3) Compact, light weight design in the volume of 6"X6"X8" and weight not to exceed 10 pounds 4) Maximum laser output power in the mid IR wavelengths (non-eyesafe).

PHASE I: Identify design methodologies, critical design parameters, and the essential component evolution of an OA closed loop detection technology necessary to achieve an architecture that is consistent with the technical goals articulated above. Develop an initial system design and provide a performance assessment of the design against the above-stated requirements.

PHASE II: Build and test the OA Missile Warning Detection System in a laboratory against the relevant threat environment. Threat optics will be provided GFE. Evaluate key elements of the system in a laboratory environment. A SECRET security clearance is required.

PHASE III: Military: Develop and build a prototype system designed to detect, locate and identify multiple IR Missile threat types at a test range. Successful development may result in technology transition into the ATIRCM/CMWS Program of Record. Commercial: Personnel optics sensing devices which have the capability to provide an instant estimate of position of personnel using direct view optics such as rifle scopes, binoculars and cameras, as well as a classification of the optic type, over wide areas will have abundant commercial applications, such as the development of security systems, personnel monitoring systems, automobile automatic pedestrian alerting systems, and a new class of advanced Homeland Security Systems. A SECRET security clearance is required.

REFERENCES:
1. DARPA Steered Agile Beam (STAB) http://www.darpa.mil/mto/stab/summaries.html

2. Naval Research Lab: TADIRCM is a Tactical Aircraft Directed InfraRed Countermeasure system. http://www.dtic.mil/descriptivesum/Y2007/Navy/0604272N.pdf

3. Infrared Data Link using a Multiple Quantum Well Modulating Retro-reflector on a Small Rotary-Wing UAV. http://mrr.nrl.navy.mil/pubs/IEEE_504.pdf

4. US Army Aircraft Survivability Equipment (ASE) Army Technology Objective (ATO); http://www.quad-a.org/Symposiums/08ASE/presentations/Troisio%20Mr.pdf

KEYWORDS: Optical, Laser, Sensor, Airborne Survivability Equipment, Missile Countermeasure Technique

A10-083 TITLE: Multi-Threat Passive Detection for Aircraft Survivability Equipment (MTD-ASE)

TECHNOLOGY AREAS: Air Platform, 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 Next-Generation Aircraft Multi-Threat Passive Detection Technology

DESCRIPTION: Currently the US Army fields separate equipment to address different individual threats to its helicopters. Excessive size, weight, power consumption, and cost are some of the issues that prevent the fielding of all the systems on all aircraft to cover the entire spectrum of expected threats. The development of one system, based on a single integrated sensor technology, could significantly lower size, weight, power and cost to the point of permitting widespread fielding of full spectrum threat protection on a greater percentage of Army rotary wing platforms. Additionally the availability of a high bandwidth sensor would likely lead to increases in systems performance, including increased probability of detection and reduced false alarm rate. This effort challenges the industry to develop a single integrated sensor concept for the protection of Army rotary wing platforms from their three primary threat classes, consisting of MANPAD missiles, ballistic hostile fire and laser targeting devices.

The sensor must be able, for each threat type, to detect, locate, provide position (range and line of bearing relative to the threat platform), provide threat type and provide this information in the form of a threat warning indication. The goal of this topic is to develop a single missile/laser/hostile-fire multi-threat warning sensor for eventual use in a multi-threat warning system with jammers on rotary platforms. The concept of stacking individual sensors that each are effective in detecting their respective class of threat, in either the ultraviolet (UV), visible, near infrared (NIR) or mid infrared (MIR) as appropriate, is both novel and innovative. When integrated into future systems, a multispectral sensor would provide several performance advantages over current sensor technologies, including an increased probability of detection and a reduced false alarm rate for threat types emitting radiation in multiple detectable bandwidths. The use of an integrated multispectral sensor would allow more comprehensive noise rejection for these threat types than current sensors allow, while also likely reducing the size and weight of future systems. Additionally, due to the wide bandwidth nature of this single sensor it would have the potential to be integrated simultaneously into a multispectral hostile fire detection system, a multispectral missile warning system, and a laser warning system.

The integrated sensor would most likely implement a stacked design capable of detecting short wavelength radiation at its top level(s) and longer wavelength radiation at its lower levels(s). This implementation is suggested by developments in the camera industry. Commercially available sensors implement this stacked design concept to separately detect visible light sources of different colors. These sensors take advantage of the differing penetration depth of visible light of different wavelengths to tune sensor response at different depths to light of different colors. This proposal suggests extending this technology to develop a sensor capable of detecting visible light, NIR, MIR, and UV radiation sources simultaneously, providing essential information on the full range of threats to Army rotary wing platforms.

Specifically this wide bandwidth sensor should be capable of detecting the emission bands of the three disparate classes of threats listed earlier, and would be intended to replace current sensor technologies in future warning and hostile fire detection systems. Other wideband sensor designs that demonstrate likelihood of reduced size, weight, and power while also providing the key capability of detecting emissions in as many of the desired bandwidths as possible would also be considered. Therefore the use of a stacked integrated sensor design is not a requirement, but is highly preferred. Some components of the sensor could be stacked while others could be mounted adjacent to one another, packaged together, and integrated electronically. Finally, a sensor design including some but not all of the above detection bands would also be evaluated if it is considered not technologically or economically feasible to create a fully integrated system. If this is the case, a sensor providing as much capability as is feasible would be considered. To reiterate, the use of integrated detectors to create a sensor with maximal bandwidth in the target regions is the ultimate goal of this proposal, however Phase I will require developing as much capability as is currently economically and technologically feasible leading into future development.

Top-level requirements for this sensor are: 1) determination of feasibility and initial design concept, 2) development of an integrated multi-threat sensor design for missile/laser/hostile-fire detection/location at tactically useful ranges, 3) detection range of > 4 km for missiles and lasers and > 1 km for hostile fire, 4) compact, light weight, low power, low cost sensor design (the design should be capable of being matured to within the size, weight, power and cost of a Common Missile Warning System (CMWS) sensor in the final developed configuration. The CMWS is the missile warning system currently in use on army rotary wing aircraft.)

PHASE I: Identify design methodologies, critical design parameters, and the essential component evolution of a passive detection multispectral single integrated sensor technology necessary to achieve an architecture that is consistent with the technical goals described earlier. Develop an initial sensor design and provide a performance assessment of the design against the above-stated requirements. Describe how this is novel technology, how it will detect/locate all of the threats, and how it is different and excels over past threat sensor designs. If necessary provide information on how the design could be expanded to include additional target bandwidths, or to stack more of the sensor components.

PHASE II: Build and test the Aircraft Multi-Threat Passive Detection Sensor in a laboratory breadboard configuration against a simulated or real threat environment. Real threats or threat simulators will be provided GFE by the USG. The performance capability of this lab-based sensor design shall be thoroughly evaluated against the three threat classes of interest. The feasibility of the sensor concept shall be demonstrated.

PHASE III: Military: Develop and build a prototype sensor designed to be effective against multiple threat types in a test range. Successful development may result in technology transition into the Common Infrared Countermeasures (CIRCM) Program of Record. Commercial: Personnel optics sensing devices which have the capability to provide an instant classification estimate of position of personnel using direct view optics such as rifle scopes, binoculars and cameras, over wide areas will have abundant commercial applications, such as the development of security systems, personnel monitoring systems, automobile automatic pedestrian alerting systems, and a new class of advanced Homeland Security Systems. A SECRET security clearance is required.

REFERENCES:
1. DARPA Steered Agile Beam (STAB) http://www.darpa.mil/mto/stab/summaries.html

2. Naval Research Lab: TADIRCM is a Tactical Aircraft Directed InfraRed Countermeasure system. http://www.dtic.mil/descriptivesum/Y2007/Navy/0604272N.pdf

3. Infrared Data Link using a Multiple Quantum Well Modulating Retro-reflector on a Small Rotary-Wing UAV. http://mrr.nrl.navy.mil/pubs/IEEE_504.pdf

4. US Army Aircraft Survivability Equipment (ASE) Army Technology Objective (ATO); http://www.quad-a.org/Symposiums/08ASE/presentations/Troisio%20Mr.pdf

5. Operation and performance of a color image sensor with layered photodiodes. http://www.google.com/search?hl=en&source=hp&q=%E2%80%9COperation+and+performance+of+a+color+image+sensor+with&aq=f&aqi=&aql=&oq=

6. Real-time color imaging with a CMOS sensor having stacked photodiodes. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.117.3713&rep=rep1&type=pdf

7. Suite of Infrared Countermeasures [SIIRCM]. http://www.fas.org/man/dod-101/sys/ac/equip/siircm.htm

8. Army Programs. http://pogoarchives.org/m/ns/dote-fy09annualreport-army.pdf

KEYWORDS: Optical, Laser, Sensor, Airborne Survivability Equipment, Threat Detection: Missile, Hostile Fire, Laser

A10-084 TITLE: Wall Characteristic Extraction for Through Wall Radar Systems

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PM Soldier Handheld Sense Through the Wall

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

OBJECTIVE: The objective is to develop techniques and algorithms to extract wall dielectric and thickness information from a standoff distance.

DESCRIPTION: The Army requires the capability to extract a wall characteristics of a building from a standoff distance. The developed techniques shall determine, at a minimum, dielectric properties, thickness and whether there is a significant metallic infrastructure (i.e. foil backed insulation) of the target wall. Also desired is the ability to determine higher fidelity information, such as material composition and/or use of reinforcement. The final results shall be the system architecture and algorithms necessary to extract wall characteristic information. This will, in turn, be utilized to improve the detection of personnel in Sense Through the Wall (STTW) systems and/or increase the fidelity of SAR based images, such as those exploited by the DARPA Visibuilding program.

PHASE I: Conduct a feasibility study to develop methods for extracting wall characteristic information while operating from DC to C-band or at leveraged through the wall radar frequencies and utilizing either stepped, frequency modulated, or impulse waveforms. Determine bandwidth, frequency, waveform, polarization, antenna and power requirements best suited to extract wall characteristics (dielectric, thickness, penetrability). Determine standoff limitations for extracting the desired information. Experiment against various wall types, to include brick, adobe, reinforced concrete, and stucco walls with or without foil-backed insulation while operating in a lab or otherwise controlled environment. Any and all laboratory equipment may be used with no time limit for processing. Determine requirements for real-world implementation with the expectation to provide information in real-time.

PHASE II: Expand the capability to extracting secondary (interior/2nd chamber) wall Information. Utilize only frequencies used by through the wall radar systems, if not already implemented in Phase I. Develop real-time techniques to extract wall information in less than 5 seconds. Develop algorithms that could be implemented in STTW, Visibuilding, or Complex and Urban Terrain Sensing (CUTS) Army Technology Objective (ATO) systems. Collect wall information in a real-world environment/Military Operations in Urban Terrain(MOUT) site, while utilizing the energy emitted by a STTW/Visibuilding/CUTS systems. The Government may provide Government Furnished Equipment (GFE) or Government Furnished Information (GFI) (handheld STTW or CUTS related devices) if needed.

PHASE III: The completion of this phase would result in a refined, robust algorithmic framework to extract wall information, methods for implementing in real-world systems, and a receiver deliverable for collecting the desired information, if necessary. Military programs that would benefit from a Phase III system are Complex and Urban Terrain Sensing (CUTS), PM Soldier Handheld Sense Through the Wall system, and Visibuilding.

REFERENCES:

1. http://www.darpa.mil/sto/smallunitops/visibuilding.html

2. https://www.fbo.gov/spg/ODA/DARPA/CMO/BAA06-04/listing.html

3. https://www.fbo.gov/notices/bb1689519b1ba379b4c200c34845f414

4. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1706221

KEYWORDS: wall dielectric, dielectric, data collection, wall characterization,through wall sensing, sense through the wall, sttw,wall thickness,data processing,standoff,synthetic aperture radar,sar,floor plan,radar,algorithm,data analysis,visibuilding

A10-085 TITLE: Scenario Based Modeling of Electronic Systems

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: Develop a complex, sophisticated software agent that will significantly improve the Army's ability to develop effective defeat solutions and allow for adaptation of the tactics and doctrine employed in a timelier manner. The software agent(s) shall automatically decompose electronic system emplacement scenarios into a form suitable for input into mature user friendly COTS Electromagnetic solver algorithms and select the optimal Electromagnetic (EM) solvers for the scenarios of interest.

DESCRIPTION: The emplacement characteristics of asymmetric scenarios are complex, and use individual, non-associated existing modeling and simulation techniques are not capable of addressing system level and operational level issues. There is a great need for a capability that can automatically and smartly associate underlying existing modeling and simulation programs by overlaying them with a sophisticated and unique program that will address system and operational level scenarios. Such an 'overlay' capability would include the ability to perform a two-way optimization of the underlying programs so that system designers and users could achieve maximum synthesis and utilization of underlying point solution algorithms and comprise a system/operational capability without the need to rewrite existing detail oriented modeling and simulation programs. For instance, there are existing accurate modeling for RF propagation and conductance of RF energy into electronic devices and sensors, however, the models address only one dimension of that required to assess overall system performance and operational impact. This overlay capability would create the capability to perform system level and operational impact trade-offs without requiring rewriting existing sub-programs. The technical challenge is to create a unique system-of-systems modeling solution which can overlay any and all existing sub-models that address one phenomenon in detail. Presently, a 'superuser' is required to decompose (based on individual level of expertise) these higher level phenomena into individual phenomena that point solution modeling and simulation programs can then address. The information resulting from the point solution models must then be 're-formed' by the 'super-user' to give a system and operational assessment of the resulting answers of the individual point solution programs. This 'overlay' modeling and simulation solution will obviate the need for the interpretation from the "super-user" and allow ordinary and field oriented users to utlize these modeling and simulation capabilities. Additionally, this overlay modeling and simulation capability will be directed at potential incorporation into live fielded systems to create scenario simulations within the fielded systems that are not presently available at the user level.

PHASE I: Investigate feasibility and trade offs involved with developing software agents that can decompose graphic representations of electronic systems and their surrounding environment and select optimal EM solvers to best satisfy the scenario of interest.

PHASE II: Develop, build, test, validate and demonstrate the software for intended scenarios on a common computer system. The software will be provided with all user documentation

PHASE III: Transition software to I2WD and Other Government Agencies. Apply tools to commercial market place EM designers; the cell phone industry and to Military end users PM CREW, DCGS-A. Transition work to IRON Symphony ATO.

REFERENCES:
1. System Architecture: The Context for Scenario-based Model Synthesis, Sebastain Uchitel, Robert CHately, Jeff Kramer, Jeff MaGee, Department of Computing, Imperial College, London, 25 June 2004

2. FIT Numerical Modeling for EMI Discovery and Design. J. Drewniak, UMR/MS&T EMC Laboratory Missouri University of Science and Technology, IEEE International Symposium on Electromagnetic Compatibility (EMC), 22 Aug 2008.

3. A Scenario based modeling method for component-based embedded software. Lui Chuanchui, Rong Mei, Zhang Guangquam, Soochow University, 21-23 Nov 2007, IEEE Symposium.

KEYWORDS: Modeling and Simulation, Software, EM, Electronic Systems

A10-086 TITLE: <u>Spectroscopic Home Made Explosive Detector</u>

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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 design, develop and build a prototype spectroscopic system for the detection of home made explosives.

DESCRIPTION: Not all explosives used in IEDs and VBIEDs are of a conventional nature such as plastic explosives, TNT or even modified artillery shells. Explosives can be made out of common items such as fertilizer and petroleum products. This type of explosive will have strong spectral lines caused by the ammonia molecules vibrational modes and intramolecular vibrations. There are spectroscopic lines in the infrared that a spectroscopic technique could take advantage of in trying to detect homemade explosives. When the combination of chemicals is mixed to make the explosive there is the possibility for the mixture to emit gaseous products which can be detected by active spectroscopic probing. There are methods presently used for the detection of explosives such as X-ray, neutron activation analysis, dogs and electronic sniffer devices. Identification usually relies on properties that are modified by the adsorption of the out-gassed by-products from the explosive. The first two techniques mentioned require sophisticated equipment, which is generally large and immovable. Dogs electronic sniffers have to be practically on top of the targets to be effective. It is of paramount importance to develop a system with stand-off detection capability that could detect trace amount of the out-gassed by-products of explosive materials, while not triggering the explosive components themselves. There have been sensors made that are able to measure down into single digits per million and this should be the goal of the unit. The system is intended for use at checkpoints but should be portable to be carried by one man and set up easily. The unit should weigh 40 pounds or less and be able to be carried by one man in a suitcase or pelican case of 2 cubic feet or less. The contractor shall develop and characterize a spectroscopic sensor that would be used to detect homemade explosives through their unique chemical characteristics. A spectroscopic technique is required that should be able to detect the explosives by scanning the interior of a vehicle or structure at a distance of up to 30 m. There are small spectroscopic systems but they do not have the ability do it at any appreciable distance. The contractor shall design a system and provide a technical discussion of why it will be successful in detecting homemade explosives. Plans for a prototype system will be discussed in the event of a phase II selection of the system. A simple interface will also be designed on a laptop which will control the system, in order to display the data in a manner in which it will be obvious that a detection has occurred.

PHASE I: The contractor shall conduct a feasibility study to develop a small lightweight, possibly portable spectroscopic sensor that would be necessary to detect home made explosives. The contractor shall submit a report which will be a feasibility study of the system used to perform this mission. The report should contain a description of the system, the method for taking the data from the system and turning this into useful information to determine if home made explosives are present.

PHASE II: The contractor shall develop a robust prototype system based on the results of the Phase I effort. The prototype system will be able to detect surrogate gaseous emissions in vehicles or structures at suitable safe distances, displaying the detection as a spectroscopic display in the prototype system ensuring that it is performing correctly. A demonstration of the system will be done at a location determined by the government.

PHASE III: Based on Phase II results the system will be improved upon and optimized for commercialization. Several specific military/ programs that can benefit from this system include forward Operation Bases, Urban Sabre ATO, Sense Through the Wall ATO, military encampments, Law Enforcement agencies, Department of Homeland Security and Customs and Border Security.

REFERENCES:
1. Sen Yang, Dongcao Song, Sanguo Li, Tom Kosica, David Li, and Hong-Liang Cui, “Portable methane gas sensor with a 1.65μm LED”, Proc. SPIE 6371, 63710P (2006).

2. Y Zhang, S Li, R Pastore, Z Yin, H Cui, “Unattended ground sensor based on fiber BRAGG grating technology”, Chemical and Biological Sensing VI. Proceedings of the SPIE, Volume 5796, pp. 133-140, 2005

3. Optical Fiber Gas Sensors for Remote Detection of Methane Gas in Coal Mines
PhD Dissertation, Stevens Inst. of Tech., 2006, Sanguo Li

4. "The power of infrared spectroscopy and spectral comparison," www.astrochem.org/NH3IR.JPG.

KEYWORDS: Spectroscopy, home made explosives, check points

A10-087 TITLE: Identification Based on Individual Scent (IBIS)

TECHNOLOGY AREAS: Biomedical, 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: Uniquely identify an individual based on scent without the use of a taggant for the purpose of tracking. This research will result in an improved method for detecting and non-cooperatively indentifying individuals based on scent from a distance (time and/or space) and its potential implementation.

DESCRIPTION: In Operation Iraqi Freedom (OIF), biometrics can be obtained cooperatively from people as they pass through checkpoints at points of entry, when they apply for employment with the new government, when detained at detention facilities, etc. Biometrics such as fingerprints, iris scans, and facial images, are collected along with relevant biographical and contextual information to be stored, fused, and exploited by the Intelligence Community. As the Overseas Contingency Operations (OCO's) transition from a permissive biometric environment, such as Iraq, to a more restricted biometric environment, such as Afghanistan, a need arises for non-cooperative biometric collection tools. This means that Counter Intelligence / Human Intelligence (CI/HUMINT), Military police (MP) and Stability, Security, Transition, and Reconstruction (SSTR) operations will need to exploit biometrics collected at crime scenes (or non-cooperatively). One such biometric that can be collected non-cooperatively and from a distance is an individual's scent.

Research has proven that an individual's scent is made up of Volatile Organic Compounds (VOCs) that can be present up to a month in normal atmospheric conditions [1]. It has also been shown that the genes of the Major Histocompatibility Complex (MHC) control and regulate several volatile organic compounds found in the urine of mice [4]. Variations in gene expression are reflected in that urine [5]. The MHC odor profile has been shown to remain despite changes to one's diet [6] ; meaning that individuals can be identified based on scent regardless of diet and time since exposure (except for identical twins) [1]. This is the premise that bloodhounds identify and track fugitives on [2]. However, the Hepper Test of 1988 proved that bloodhounds were accurate 89% of the time, and therefore K9 scent identifications should be admissible in court [3].

This SBIR looks to leverage the numerous studies and research efforts that have been conducted in order to refine the ability of uniquely identifying an individual based on the MHC controlled odor profile. An example of the current state-of-the-art technology includes an Electronic Nose (E-Nose) capable of detecting human odor from the armpit region and being able to distinguish between the odors of two different people [7]. This project will determine which VOCs shall be collected in order to increase the confidence of accurately identifying an individual on scent, as well as potential collection techniques.

PHASE I: Conduct a feasibility study to determine the necessary VOCs and respective concentrations that need to be collected for exploitation. Conduct a study on what matching algorithms will be required to uniquely identify an individual. Show how the confidence in uniquely identifying an individual degrades over time.

PHASE II: Develop the Phase I algorithms necessary to uniquely identify an individual based on their genetically controlled VOCs. Design a test method, sample size, and evaluation criteria to verify and validate (V&V) the algorithms. Construct a prototype and establish proof of concept for the device that will collect the required VOCs. Deliver software products, documentation and demonstration improving state-of-the-art technology.

PHASE III: The technologies developed in Phase II that have commercial potential will be further refined for transition in Phase III. Military applications will include transition to PM Biometrics for further refinement and potential integration into the Biometric Enterprise, as well as integration into DOD Automated Biometric Identification System (ABIS) as another biometric modality. Commercial uses will include transitions to federal law enforcement, such as the FBI, DEA, USMS, and ATF, state and local law enforcement for the purposes of identifying and tracking persons from the scenes of various crimes.

REFERENCES:

1. Curran, Allison M., Rabin, Scott I., and Furton, Kenneth G. "Analysis of the Uniqueness and Persistence of Human Scent." Forensic Science Communications 7(2) (April 2005).

2. Jenkins, Stephen H. "The Mythic Infallibility of the Dog." How Science Works: Evaluating Evidence in Biology and Medicine. Oxford University Press, Inc. 2004. Pgs 38-39.

3. Carlton, Jeff. "Innocence Project Finds Fault with Scent Identification Line-ups." Lubbock Online. September 2009.

4. Beauchamp G.K., Yamazaki, K. "Chemical Signaling in Mice". Biochemical Society Transactions. 31. Pgs. 147-151. 2003.

5. Restrepo, D., Lin, W., Salcedo, E., Yamazaki, K., Beauchamp, G.K. "Odortypes and MHC peptides: Complementary chemosignals of MHC haplotype". Trends Neurosci. 29. Pgs. 604-609. 2006.

6. Kwak, J., Willse A., Matsumura K., Curran Opiekun M., Yi W., Preti G., Yamazaki K., Beauchamp GK. "Genetically-based olfactory signatures persist despite dietary variation". Plus One. 3(10)e:3591. 2008.

7. Wongchoosuk, C., Lutz, M., Kerdcharoen, T. "Detection and Classification of Human Body Odor Using an Electronic Nose". Sensors. 2009; 9(9). Pgs. 7234-7249.

KEYWORDS: OlfactoryScentVOCs – Volatile Organic CompoundsMHC- Major Histo-compatibility ComplexCI/HUMINT – Counter Intelligence / Human IntelligenceMP – Military PoliceSSTR – Stability, Security, Transition, and Reconstruction

A10-088 TITLE: Forensic Facial Image Analysis providing 3D Mapping, Metatagging, Comparative Operation and Search System

TECHNOLOGY AREAS: Information Systems, 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 an automated system for identifying distinguishing features on faces and other significant body parts such as moles, scars, tattoos, piercings and other abnormalities, to assist in the linking of otherwise unidentified individuals across a geographically enabled database. Establish a framework capable of searching the database through biometric and contextual feature information across repositories to track and/or identify a Person of Interest (POI).

DESCRIPTION: With the current Global War on Terrorism (GWOT) and future efforts to extend beyond that, biometric-enabling capabilities will continue to emerge at the forefront for identifying and tracking adversaries of interest. The high volume of facial imagery produced from a multitude of sources makes it difficult for analysts to identify multiple instances of an otherwise unidentified individual across a data repository with geographic metadata. As biometrics continues to emerge as an enabling capability, there will be a necessity to continually refine the process in which biometrics are stored, analyzed and managed. With the ever increasing amount of stored biometrics within many repositories, the analyst's task to uniquely identify individuals on hard biometrics (fingerprints, iris scan, DNA, etc.) becomes ever more difficult. The caveat to this is those stored biometrics have associated information that is used to further identify an individual. There are already standardized methods of transporting biometric and the information associated with it. The issue arises in the uniqueness of these traits. If the uniqueness of a fingerprint is 10-6, then in a database of several million individuals the time it will take to uniquely identify someone with substantial confidence is increased (Chen et. al). One such solution is to increase the number of modalities captured to uniquely identify an individual. Though this has shown to increase accuracy (Chen et. al), there exists yet other ways within the field of biometrics to efficiently make use of the information already available. In addition to this, the need for developing more refined methods of non-contact biometric identification is increasing. For improved identification, the potential affordances offered by automated techniques compared to human descriptions are distinct and complementary (Samangooei et. al).

To accomplish this, there are methods already used by law enforcement to identify individuals in such a way. These are considered the soft biometrics including height, weight, eye and hair color and information of that nature. However, these are less unique than those used by law enforcement such as scars, marks and tattoos (SMT) (Lee et. al). SMT generally present more unique information on an individual and can be used to also link individuals to each other and groups (Lee et. al). By combining this information with already present biometric and biometrically associated information through an automated process, the analyst will be able to optimize effort and time in processing information on identifying POIs. This is essentially a set of algorithms that could be incorporated into a biometric database or used separately to identify potential POIs through SMT. However, it is not limited to just algorithms but necessities such as a data dictionary and ontologies would need to be incorporated for a successful way to search and match distinguishing features much like the semantic description used currently (Samangooei et. al). A more robust feature is necessary to identify off of facial images containing SMT where the images must be precisely mapped to a three dimensional coordinate system. This will be useful for enhancing robustness to variations of the presentation of the face in disparate images accommodating all face rotational angles. Lack of an accurate and automated system for linking previously unidentified persons across geographic and temporal space makes it extremely difficult to track potential Persons of Interest. This research is to result in proposed improvements and methods to find and track POIs based on biometric and contextual facial feature information.

PHASE I: Determine the most significant and relevant distinguishing facial features necessary to be mapped for identifying POIs. Provide a feasibility study on identifying POIs based off of distinguishing facial features and associated contextual information in a net centric environment.

PHASE II: Develop a framework and methods for automating the association of multiple instances of otherwise unidentified individuals through the automatic mapping of distinguishing facial features. Propose scenarios, evaluation methods, and use of test samples. Determine the measure of effectiveness and performance parameters to be tested. Construct a prototype and establish proof of concept. Complete spiral development refinement of framework and algorithms. Deliver software products for government evaluation, documentation and demonstration improving state-of-the-art technology.

PHASE III: The technologies developed in Phase II that have commercial potential will be transitioned in Phase III. Military applications will include a transition to PM Biometrics and/or PM DCGS-A to ensure interoperability with other military ground systems and will also be interoperable with other DoD agencies whose information may be fused into biometrics intelligence reporting. Developed products will have wide use in commercial markets. Market segments include fraud, identity theft, criminal deceit, personnel security, biometrics management, and safekeeping, information integrity, and protection. Commercial uses will include transitions to federal law enforcement, such as the FBI, DEA, USMS, and ATF, state and local law enforcement.

REFERENCES:
1. Handbooks in Information Systems: Volume 2. National Security. Chen H, Raghu TS, Ramesh R, Vinze A, Zeng D. Amsterdam, The Netherlands, 2007, page(s): 101-131.

2. "Scars, marks and tattoos (SMT): Soft Biometric for Suspect and Victim Identification", Lee JE, Jain AK, Jin R. East Lansing, MI, USA, Proceedings of the 2008 Biometrics Symposium IEEE, 2008, page(s): 1-8.

3. “The Use of Semantic Human Description as a Soft Biometric”, Samangooei S, Guo B, Nixon MS. Arlington, VA, USA, 2nd IEEE International Conference on Biometrics: Theory, Applications and Systems, 2008, page(s) 1-7.

KEYWORDS: Biometrics, Intelligence Analysis, Distinguishing Features

A10-089 TITLE: Tactical Counter Concealment Aerial Sensors Electronic Protection (TC-CAS EP)

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.

DESCRIPTION: Tactical Counter Concealment Aerial Sensors (TC-CAS) that are currently being developed by the Army operate at VHF, UHF and or L-band frequencies. These radars must operate in environments in which there can be a significant amount of unintentional RFI (i.e. communications, terrestrial broadcast,), operating in close proximity to systems operating in similar radar bands, and /or possibly intentional Electronic Attack (EA). The Radio Frequency Interfrence (RFI) and/or EA, which are received through the systems receive antenna's mainlobe, sidelobes, and/or backlobes, could significantly degrade the image quality and or adversely affect system capability.

This effort will develop one or more software techniques to adapt to the ambient Radio Frequency (RF) environment and then mitigate the effects of RFI and/or EA through interaction with existing system hardware / parameters when a predetermined threshold is reached. The Raw data necessary for this already exists in the radar's signal processor. The variable threshold would be dependent on the chosen sensor system and the band in which the RFI is detected. The algorithm can utilize the system's raw radar data to determine the interference. Mitigation for example can be realized via adaptive waveform notching or other dynamic RFI rejection. The algorithm should be robust to dynamic changes in ambient RF environment and should allow for autonomous reconfiguration of system parameters as soon as feasible in order to cancel the effects of new interference. The system should continuously monitor the environment and remove or add additional notches/adaptation as required.

PHASE I: The Contractor will select a representative sensor to focus analysis efforts and investigate one or more innovative software Electronic Protect (EP) concepts. The study should show through analysis and/or a basic simulation how the proposed technique(s) could utilize existing sensor parameters and or sensor hardware to improve target detection ability in a TC-CAS Synthetic Aperture RADAR (SAR) system. The proposed technique(s) should also demonstrate additional system capability in the presence of strong RFI and/or EA emissions. The study should address optimal hardware specifications (i.e. sensitivity, number of channels, antenna characteristics, etc.) necessary to support the algorithm(s) proposed. The study should also address the adaptive system's update rates in terms of how much data must be collected for detection and thresholding, as well as the possible timelines for injecting the adaptation parameters into the Radar system's collection waveforms (i.e. during a coherent interval, between intervals, X number of intervals/pulses, etc.). The algorithm should also be robust against changes to input data if possible. Typical TC-CAS systems may not be operating with constant parameters as imaging tasks will change often during a mission. Changes to image requirements will bring about commensurate changes in system waveform bandwidth and length, etc.

PHASE II: The contractor should develop a prototype consisting of detailed software simulation to demonstrate how well the proposed EP techniques(s) would perform in a complex EA and RFI environment. Also, the contractor will apply the techniques developed under Phase I to available test data provided by the Army system or conduct a data collection to obtain such data.

PHASE III: The contractor will work with I2WD and/or the radar manufacturer to integrate the solution into a Counter Concealment Aerial Sensors (C-CAS) radar system for military applications or similar Department of Homeland Security application to decrease vulnerability to RFI and/or Electronic Attack of radar systems.

REFERENCES:
1. Brian Fisher, Ivan LaHaie: “Demonstration of a Network of Simultaneously Operating Digital Noise Radar”, IEEE Antennas and propagation Magazine, Vol 51, No. 2, 2009, pp 125-130

2. Isak Theron, Eric Walton, Suwinto Gunawan, Lixin Cai: “Ultrawide-Band Noise Radar in VHF/UHF Band”, IEEE Transactions on Antennas and Propagation, Vol 47 No. 6, 1999, pp 1080-1084

3. Zhixi Li, Ram Narayanan: “ Doppler Visibility of Coherent Ultraband Random Noise Radar Systems”, IEEE Transaction on Aerospace and Electronic Systems, Vol 42, No.3, 2006, pp 904-916

4. Lai C.P., Narayanan R.M, Culkowski G.: “Through the Wall Surveillance using Ultrawideband random noise radar” 25th Army Science Conf., Florida, Orlando, 27-30 Nov 2006, pp 1-4

5. XU Y., Narayanan R.M., XU X., Curtis J.O: Polarmetric processing of coherent random noise radar data for buried object detection”, IEEE Transaction Geoscience Remote Sensing , Vol 39 No. 3, 2001. pp 467-478

6. T. Suzuki, I.Arai: “Advances in Underground radar” IEICE Transaction, Vol E74, No. 1 1999

7. L. Peters , J.J. Daniels, J.D. Young: “Ground Penetrating Radar as a subsurface Environmental Sensing Tool”, IEEE, Proc., Vol 82, NO.9, 1994, pp1802-1822

8. Richard Dubroff, S.V. Marshall, & G.G. Skitek. "Electromagnetic Concepts and Applications". New Jersey: Prentice-Hall, Inc; 1996. Print.

9. Merrill Skolnik. "Introduction To Radar Systems". New York: McGraw Hill; 1980. Print
L.A. Bessette and S. Ayasli, “Ultra-Wideband P-3 and CARABAS II Foliage Attenuation and Backscatter Analysis,” IEEE 2001 Radar Conf., Atlanta, GA, May, 2001.

KEYWORDS: Counter Concealment Aerial Sensors, Penetrating radar, Optimal waveform

A10-090 TITLE: Visualization Tools for Causal Data Mining

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop an interrelated extensible tool suite that is highly graphical and permits users to better understand causal relationships between large data sets. This toolkit should function by allowing a user to discover relationships between seemingly unrelated events in order to solve problems.

DESCRIPTION: A number of Army problems center around the need to discover patterns in large quantities of data that act as causal markers for subsequent events. Attempting to find relationships in intelligence data is typical of this type of data searching. For example, an Intelligence Officer may not really know specifically what he is looking for, but he is looking for causal patterns in what appears to him to be unrelated information. This is also the same problem maintenance engineers have when searching vehicle health information when performing Condition Based Maintenance.

Data mining, a tactic frequently used in retail and other commercial areas, involves analyzing data from different perspectives and discovering information on a topic through the relationships found between the data. In the commercial sector, this type of system could be used in order to discover customer patterns. With this information, the company would then be able to advertise or sell their product in the most effective way targeted toward their customers’ habits. These same concepts of data mining are applicable for Army use in cases such as those previously mentioned.

For this SBIR, the contractor will develop a graphical tool suite that allows users to more effectively find and understand causal relationships between large data sets. The solution should be interoperable with existing Army C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) systems, such as TIGR (Tactical Ground Reporting), CPOF (Command Post of the Future), and DCGS (Distributed Common Ground System). The contractor should be able to demonstrate system effectiveness in the two main areas of Intel and Condition Based Maintenance. In Intel applications, the system should allow the user to graphically "see" causal patterns in intelligence data leading to specific outcomes or events, enabling them to prepare for the events when they notice those patterns occurring at later points. The system's application to Condition Based Maintenance would involve allowing the user to find relationships and patterns in data leading up to a breakdown or malfunction in some equipment, thereby enabling the system user to recognize the precursors to such an event occurring on the actual equipment. This then allows maintenance engineers to provide needed maintenance to such equipment before it breaks down in the future, which can be disastrous in the field. The contractor will need to ensure that algorithms are used which provide predictive maintenance capabilities for smaller populations of equipment (under a few thousand) that contain the same functionality as those used commercially in the auto industry which normally require larger populations to function effectively. In addition to tools with Intelligence and Condition Based Maintenance applications, the Army will also accept proposals that include other applicable areas for this type of causal data mining tool.

PHASE I: Phase I of this project would involve extensive research of work already conducted in this area, followed by an analysis of alternatives and documentation of the strengths and weaknesses of the possible approaches. An approach will be selected, and the system will be designed accordingly. This design must include tools to conduct the data mining and pattern finding, as well as a graphical interface to allow users to easily see the relationships between the data. The deliverables from this phase will include the analysis of alternatives and the system design.

PHASE II: Phase II activities would include building and demonstrating the system which is able to detect patterns and relationships between seemingly unrelated sets of data. The demonstration must show how the system will function in actual Army-based situations using relevant and representative data. To accomplish this, the contractor must propose and demonstrate use of the system using a realistic Army use case. The contractor must work with TRADOC (U.S. Army Training and Doctrine Command) and relevant Project Managers and Subject Matter Experts to design the use case. The scenario must demonstrate the system's capability to find relationships and patterns between large sets of data, consistently leading up to the occurrence of a particular event. The solution will also be tested in a live experiment, for example at PM C4ISR OTM ("On The Move"). The deliverables for this phase will include the functional tool suite, the use case, and the demonstration, as well as the runtime and design documentation.

PHASE III: Phase III involves the commercialization and deployment of the system. The ability to find patterns and relationships between large sets of data, and exhibit these relationships in a way that is easy for a user to see is applicable to and helpful for gleaning information from intelligence data and performing Condition Based Maintenance on other Army equipment. The concepts used in commercial data mining can be applied toward this effort. Data mining is frequently used in the area of retail sales to predict consumer responsiveness to a product or advertising scheme. The same principles used for pattern finding in these areas can be applied to the Army's Intel and maintenance needs. The proposed system, however, must be able to take smaller populations of equipment into account (as similar commercial systems often require a larger sample) in order to meet Army-specific predictive maintenance needs.

REFERENCES:
1. Thearling, Kurt. "An Introduction to Data Mining", http://www.thearling.com/text/dmwhite/dmwhite.htm

2. Silverstein, Craig; Brin, Sergey; Motwani, Rajeev; Ullman, Jeff. (1998) "Scalable Techniques for Mining Causal Structures" http://www.vldb.org/conf/1998/p594.pdf

3. "Tactical Ground Reporting (TIGR)", http://www.ascendintelligence.com/tigr.htm

4. "Command Post of the Future", General Dynamics (2006), http://www.gdc4s.com/documents/cpof-9-12-06.pdf

5. “Distributed Common Ground System – Army (DCGS-A)”, General Dynamics (2008), http://www.gdc4s.com/documents/DCGS-A.pdf

6. “PM C4ISR On-The-Move”, http://www.cerdec.army.mil/directorates/pmc4isr.asp

7. "Fixing Intel: A Blueprint for Making Intelligence Relevant in Afghanistan", MG Flynn http://www.cnas.org/files/documents/publications/AfghanIntel_Flynn_Jan2010_code507_voices.pdf

KEYWORDS: Data Mining, Pattern Finding, Condition Based Maintenance

A10-091 TITLE: Adversarial Reasoning for Combined Unmanned Aerial Systems (UASs) and Unmanned Ground Vehicles (UGVs)

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

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Design, develop, and demonstrate a mission execution framework and software application to enable tracking and surveillance of uncooperative targets by combined teams of UASs and UGVs.

DESCRIPTION: This research effort will focus on the development of a Battle Command framework to support collaborative teaming of Unmanned Aerial Systems (UASs) and Unmanned Ground Vehicles (UGVs) to enable autonomous target tracking in the inherent challenge of clutter and occlusions in urban and complex environments. To add to this challenge, adversarial targets will attempt to evade detection though complex maneuvers and utilization of natural and manmade terrain features. This topic is not intended to address automatic target recognition nor target identification. Rather, the focus shall be the development of the algorithms to characterize and predict elusive target behavior and the mission execution framework to direct the collaborative actions between multiple, heterogeneous unmanned air and ground vehicles. Additionally, this execution framework shall be extensible to other collaborative missions beyond target tracking. Dismounted operators at the tactical edge will input high-level tasks into the application via a handheld mobile device while the mission execution framework would decompose missions into their underlying tasks and represent these actions by a common descriptive language. Coupled with adversarial reasoning algorithms to characterize and predict target behavior, the software would optimally sequence and allocate tasks across the team of UASs and UGVs to maintain target tracking. This application is to be run on a handheld device running an operating system such as the Apple iPhone OS, Android, Windows Mobile, or similar environment. Furthermore, this requires the development a novel user interface to manage the mission throughout execution. Such an interface would leverage recent advances in multimodal inputs including multitouch, gesture and voice recognition to mitigate the cognitive load placed on the Warfighter. The execution of the mission by the unmanned vehicle team is to primarily autonomous, however the operator shall have the ability to monitor mission status, input new tasks, and update mission goals. Examples of interaction may include free-hand path planning/drawing, image and video management, or map manipulation.

PHASE I: Analyze how the Army currently uses UASs and UGVs to perform visual target tracking missions and develop a conceptual mission execution framework for collaborative missions. Research shall include development of algorithms to characterize and predict elusive behavior by the target. Additionally, the offeror will provide a plan for practical deployment of the proposed solution the Warfighter in an operation environment.

PHASE II: Build and demonstrate a prototype software application on the basis of Phase I study which implements mission execution framework to deploy a team of UASs and UGVs to autonomously track an evasive target. Phase II research shall include design and development of a multi-modal user interface. Application shall be demonstrated on an applicable handheld device running an operating system such as the Apple iPhone OS, Android, or Window Mobile. Level of autonomy shall be demonstrated along with an assessment of operator workload during mission execution.

PHASE III: Finalize development of UAS and UGV visual target tracking application. Identify opportunities for insertion into existing current and future force C2 systems such as FCS Battle Command and the Joint Battle Command Platform (JBC-P). Additional commercial applications of the mission execution framework and target tracking application may include Homeland Security, Boarder Patrol, and local law enforcement organizations.

REFERENCES:
1. M. Moseley, B.P. Grocholsky, C. Cheung,S. Singh. "Integrated Long-range UAV/UGV Collaborative Target Tracking" Proceedings of the SPIE, Volume 7332 (2009)., pp. 733204-733204-11 (2009).

2. A. Kott. "Battle of Cognition", Praeger Security International, 2008.

3. S. Russell and P. Norvig. "Artificial Intelligence A Modern Approach - Second Edition", Prentice Hall, 2003.

4. US Army Field Manual FM 3-04.155 Army Unmanned System Operations
US Army Field Manual FM 5.0 Military Decision Making

KEYWORDS: Command and Control, UAS, UGV, Multi-touch, Gesture

A10-092 TITLE: Contextual Framework for Command and Control Decision Making

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Perform research into the definition, representation, measurement, and manipulation of a Commander's contextual framework as he interacts with a Command and Control system, in order to help him gain increased situation awareness and, as a result, help him to make better decisions more quickly.

DESCRIPTION: A Commander's contextual framework helps him to analyze data and information at his disposal in order to make command decisions. It may include, but is not limited to, his background, education, experiences, intelligence, memory, creativity, relationships, and trust in tools and individuals. The contextual framework helps a Commander to use data and/or information from disparate sources (both software tools and people) to gain increased awareness and understanding of the situation he is involved in, and can help him to project possible future impacts of specific actions that he may make as a result of this data and information.

Command and Control systems are designed with context as an inherent consideration - workflow, rules and logic in the software, the user interface, and so on are all based on the context of the problem being solved and the decision being made. However, there are aspects of context that are truly dynamic and personal, and can only be discovered as the Commander interacts with a unique and constantly evolving problem set and with systems and fellow warfighters similarly engaged in a specific scenario. The underlying goal of this research is to study issues pertaining to the enhancement of a Commander's understanding of a situation by the consideration of a contextual framework that can be associated with a set of data and information.

Research areas to be considered include, but are not limited to, the following:
(1) the elements that define a contextual framework for this class of problems
(2) the representation of a contextual framework
(3) the measurement of a contextual framework (from monitoring certain aspects of the Commander's interactions with systems and other warfighters)
(4) the association of portions of a contextual framework with data and/or information
(5) the sharing of portions of a contextual framework between warfighters for enhanced situation awareness
(6) the operations to manipulate a contextual framework in order to improve the Commander's cognitive understanding of the situation at hand

PHASE I:

(1) Investigate the concept of a contextual framework and identify all elements that should be considered for inclusion in the study. Perform a feasibility study to ascertain which elements should be included in a prototype conceptual framework. Feasibility analysis should consider not only potential payoffs but the level of difficulty in capturing, manipulating, and using the data.
(2) Develop an initial design that describes how a contextual framework would be implemented in a dynamic command and control system. Sample workflows that demonstrate the use of specific elements from the contextual framework should be included for illustrative purposes.
(3) Investigate software architecture, network, and database issues associated with the inclusion of a framework in a command and control system.

PHASE II:
(1) Describe a detailed design for the inclusion of a contextual framework in a command and control system.
(2) Develop a prototype contextual framework and implement it as part of a command and control system.
(3) Demonstrate the application of the contextual framework to a commander's workflow in a representative operational scenario.
(4) Demonstrate the sharing of portions of a commander's contextual framework with another commander with a different contextual framework.

Deliverables will include:
a written document describing the contextual framework
a functional prototype
a written report that details the results from (3) and (4) above

PHASE III: A contextual framework that could be used to improve an operator's performance would have applicability not only to command and control systems, but to many other military applications (fire support systems, in-flight pilot assistance software, supply and logistics management, etc.). A framework could have many different commercial uses as well - air traffic control, financial analysis, medical diagnostics, etc. In general, any system that relies on the experience and expertise of the user to analyze data and information and make a decision could be a target for application of a contextual framework.

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

REFERENCES:
1. Battle of Cognition, The Future Information-Rich Warfare and the Mind of the Commander, edited by Alexander Kott, Praeger Security International, Westport, Connecticut

2. Tactical Human Integration of Networked Knowledge (THINK) Army Technology Objective - Research (ATO-R)

KEYWORDS: command and control, contextual framework, situation awareness, cognition

A10-093 TITLE: Intelligent Human Motion Detection Sensor

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Design and build a small and inexpensive human motion detection sensor that can quickly and with reliable accuracy detect various types of human motion such as: stationary, slow/fast walking, slow/fast running, walking sideways, walking backward, crawling, walking upstairs /downstairs, jumping, and etc. Information from this sensor could be used to enhance the position estimation of Soldier platforms in Global Positioning System (GPS) degraded and denied environments.

DESCRIPTION: Future Force dismounted Soldiers will be required to operate in areas with poor GPS signal availability, such as in buildings and caves. Future Combat Systems (FCS) Future Operating Capability (FOC-05-01) requires position/navigation to a 1-meter Circular Error Probable without continuous electronic emission. A self-contained navigation sub-system is desired to provide this capability. The currently implemented Land Warrior Navigation Sub-System (LWNSS) is an integration of GPS, digital compass, barometer, and pedometer. However, the pedometer operates on the assumption that every detected step will be forward only. This can introduce a large error into the overall position estimation should the Soldier perform movements other than walking forward. This topic calls for an advanced human motion detection sensor to be used as an aid for an integrated navigation system. These intelligent sensors are expected to perform better than the current pedometers used in the LWNSS. The topic puts major emphasis on Size, Weight, Power, and Cost needs for the dismounted Soldier and other small sensor platform applications. Potential technologies can include MEMS IMUs and MEMS accelerometers among others.

PHASE I: Develop sensor approaches for characterizing various types of human motion such as: stationary, slow/fast walking, slow/fast running, walking sideways, walking backwards, crawling, walking upstairs /downstairs, jumping, and etc. The result of the process must provide a specific signature for each type of motion. Perform a feasibility study that determines the technical merit and of the selected method for use in real time position estimation techniques. Develop and demonstrate an algorithm that can reliably and quickly identify types of human motion based on the selected sensor inputs.

PHASE II: Design and build a prototype of the human motion detection sensor based on the work from Phase I. Develop an algorithm that takes the sensor inputs to enhance the platform position estimation. Incorporate the algorithm into the sensor prototype and demonstrate the sensor performance on a real person. The sensor must quickly and reliably detect various human motion with 95% accuracy in GPS denied environment.

PHASE III: Enhance and refine the sensor design taken into the account of small size, weight, power, and cost. The end product must have an embedded system form factor that can be integrated into the future ground soldier navigation system.

Going beyond the military application, the commercial applications for this type of product are not significantly less important. In Homeland Security, for example, rescue persons entering a burning building or a tunnel where GPS is not available, or robots entering a damaged nuclear reactor to perform similar search and rescue efforts. In physical training or exercises, for example, an intelligent pedometer will provide more accurately not only what types of motions the working-out person is performing, but also the number of calories burned from his/her motions based on strides, height, and the weight of that person. The device will in turn promote people's weight-loss effort. Studies show that pedometer use is an effective intervention for promoting physical activity. Another commercial application of this technology is tracking people in GPS degraded environments. One example is tracking hikers in deep wooden areas where they have great potential for getting lost.

REFERENCES:
1. Davrondzhon Gafurov and Einar Snekkenes, "Gait Recognition Using Wearable Motion Recording Sensors", EURASIP Journal on Advances in Signal Processing Volume 2009 (2009), Article ID 415817, 16 pagesdoi:10.1155/2009/415817; http://www.hindawi.com/journals/asp/2009/415817.html

2. US Army CERDEC, “Future Force Warrior Navigation Sub-System Performance Evaluation Test Report", August 2008.

3. (Ref. 3 is no longer valid, and has been deleted 06/04/10.)

KEYWORDS: Human Motion, Detection, MEMS, Accelerometer, Navigation, GPS Denied Environment

A10-094 TITLE: Advanced Thermoelectric Milli-Power Source

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To develop a high performance milliwatt power generating source by integrating an very low weight thermoelectric (TE) energy generator with the power management architecture to recharge battery on the body while the users are on the move. The milli-power source will be based on an energy harvesting system using state-of-the-art thermoelectric technology that allows one to generate more than 2mW per cm2 of surface area, with only a 2-degree temperature difference between the body surface temperature and the outside body temperature (outside clothing or uniform). It will include an efficient boost circuit to convert the low voltages of the thermoelectric power generator to levels that are useful for recharging the battery on the body. In addition, it will provide a cooling or heating effect on the body. The system will require power management control at the transistor and circuit level to minimize overall power consumption, while providing maximax power to recharge the battery when needed.

DESCRIPTION: Energy can be harvested from many sources such as wind, solar, vibrations, temperature differentials, etc. The challenge is that the amount of energy available at any one time from some of these sources is quite small, and thus a method for capturing and storing the power for later use is required. The devices must also have low signature for covert surveillance missions. Furthermore, to maximize power generation, an approach is needed that can harvest energy over the broad operating conditions. This limits the use of solar approaches that don't work at night and vibration approaches that have very limited operating environments. Thermal gradients, however, are available between the skin body temperature and ambient air year round both during the day and at night. Estimates of absolute average daily temperature gradients between the body skin temperature and air temperature range from 4.5 to 5.8°C in the field environment throughout the year. This makes thermoelectric energy harvesting an ideal approach over broad operating conditions.

PHASE I: This phase of the program is to demonstrate the validity of the technical approach by analysis, modeling and simulation, and verification with some use of off-the shelf hardware. In particular Phase I needs to define body temperature and power available, research methods for boosting low VDC, design voltage booster unit, design power storage and control unit, develop power source architecture and establish form factor for product.

PHASE II: Based on the results of phase I, the designs of all of the parts of the system will be optimized and developed. Study the feasibility of processes allowing to make these materials on a large scale - to make the low cost production possible. At least three wearable prototype systems will be built and their performance verified in the lab. prototype system will be delivered for testing and demonstration on the soldiers.

PHASE III: A development of autonomous unattended power generating sources where they can be recharged by the Land warrior battery and/or BB-2590 lithium ion battery. A pilot line and small scale production will be set-up, with large manufacturing and low cost in focus. A sufficient number of small production prototypes will be delivered for testing and demonstration purposes. This will be a great application for the policemen, construction worker, or someone working or playing outdoor and they want to cool down or heat up during the cold and hot environmental condition. It will sell itself to consumer market.

KEYWORDS: generating power, natural air conditioner, recharger, thermoelectric, micro-power, energy harvesting, low voltage electronics

A10-095 TITLE: Consistent Visualization Across Battle Command Systems

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Software to Achieve Consistent Visualization Across Command, Control, Communications, Computers, Intelligent, Surveillance, and Reconnaissance (C4ISR) Systems. This effort will provide developers with a way of creating consistent C4ISR software user interfaces, independent of programming language and environment. The goal would be to use the project's deliverables as a future development standard.

DESCRIPTION: The Army has expressed a need to unify its Battle Command systems. One of the key concepts behind the Unification of Battle Command is a consistent user visualization experience across C4ISR software. As used here “consistent” means that the overall form and function of the user interface is the same without forcing an identical interface. For example, a consistent interface would permit different shaped buttons, but the location and function of a button would be the same. A consistent visualization will reduce training costs and improve Warfighter effectiveness. For various technical reasons, Battle Command systems are implemented using differing technologies. As a result, it is difficult or impossible to dictate the adoption of a specific visualization technology, such as X-Windows or Windows Presentation Foundation (WPF). Forcing the adoption of a specific technology could stifle the introduction of important visualization innovations and reduce important developer autonomy.

The focus of this SBIR will be to develop the technology that permits creation of a consistent user interface across C4ISR software platforms and computer types. The contractor must keep in mind that “‘consistent user interface” does not mean adopting the same implementation (e.g. everyone uses WxWidgets or Qt, for example), but rather providing developers a way to create user interfaces that are independent of programming language and environment; furthermore, permitting individual development organizations to have the freedom to select specific visualization technologies. In addition, the approach must also support tools to design user interfaces as well as automated mechanisms to check user interface designs for consistency and adherence to whatever standards the Army may have at the time. In addition, the solution should also address the way in which interface components interact with each other on the screen and the methods by which interface components are able to interact with data sources and sinks.

PHASE I: In the context of the existing state of the art, research and specify an approach to and a design for the system. The design must specifically address the creation of consistent C4ISR System user interfaces while not requiring the adoption of a specific visualization technology. The Phase I deliverables will include the system design and an analysis of how the approach meets the specified needs and is applicable to popular visualization technologies such as X-Window, MS-WPF, and smart phone user interfaces.

PHASE II: Build and demonstrate the system. Software deliverables should demonstrate how existing C4ISR systems could incorporate a new and consistent user interface based on the research and design work performed in Phase I. This might include systems such as those found in the Battle Command Framework, Force XXI Battle Command Brigade and Below (FBCB2), smart phone applications on different hardware platforms, and browser-based web applications. While the approach for this Phase of the SBIR should utilize examples drawn from specific Army systems, the proposed solution must be flexible enough to be extended to support additional C4ISR systems as well as commercial information systems.

PHASE III: A consistent user interface for displaying C4ISR data visualization would have application across all domains and echelons of the Armed Forces as well as any suite of commercial applications that require users to be proficient with multiple tools. This is in support of Tactical Battle Command Systems, PEO Integration, and the COBRA ATO (D.C4.2009.03).

REFERENCES:
1. User Interface Markup Language, http://en.wikipedia.org/wiki/User_interface_markup_language

2. Windows Presentation Foundation: XAML Overview, http://msdn.microsoft.com/en-us/library/ms752059.aspx

KEYWORDS: C4ISR, Battle Command, GUI, Visualization, Consistent Visualization, User Interface, Data Description Language, X-Windows, Windows Presentation Foundation, WPF

A10-096 TITLE: Use of Nanotechnology to Enhance Power and Energy System Performance

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: To migrate breakthroughs from basic research efforts in nanoscience and nanotechnology as they apply to improved performance of power electronics applications. Solutions that can be integrated initially into the

3 kW Tactical Quiet Generator (TQG) and scaled for emerging less than 3 kW power systems that support the Warfighter and can enhance battle system capabilities are sought.

DESCRIPTION: Recent breakthroughs in nanoscience and nanotechnology have the potential to form the basis for the development of various enabling power generation technologies for the 21st century. These sophisticated new materials are regarded as critical building blocks for future tactical power devices and systems and are poised to radically transform and enable numerous current and future tactical battlefield applications.

The Army seeks to transition the results of research efforts in nanoscience and nanotechnology from the lab to practical, proof of concept solutions in power electronics for military generator sets. Nano-technological application to switching devices, transistors, and thermal management that improve power electronics efficiency power density and environmental performance are sought.

This application of new materials shall address processing, structure, properties, performance, and application (down to the micro and nano scales) for Power Electronic Controls. The resulting power electronics design should enable the Army to improve the operational capability and reliability of existing power systems in the 3 kW and less range. Initial solutions that can be integrated into the 3kW TQG and later scaled for emerging less than 3 kW power systems are sought. Material adaptation and advancement efforts have to potential to lead to significant evolutionary improvements in the operational and performance capabilities of traditional power electronic components and subsystems. The power electronics design shall focus on:

- increasing power density by 20% (reduced log footprint)
- enabling continuous delivery of rated power in extreme tactical environments,
- improving fuel utilization (reduced fuel costs/logistic resupply and
- enabling the use of new manufacturing processes and potentially reduce O&S costs.

PHASE I: PHASE I: The contractor shall explore/identify/specify existing and future nanotechnologies, which include but not limited to nanofluids, nanocoatings and nanopowders, that can be applied to improve the efficiency, power density and environmental performance of a power electronics system for integration with the 3 kW TQG. (It should be noted that the 3 kW TQG is equipped with a Permanent Magnet Alternator and an inverter.) Based on the results of this study, the contractor shall provide a detailed design which applies selected nanotechnology solutions to the power electronics system. Modifications to components / subsystems shall leave the power electronics electrically and environmentally compatible with tactical applications. The design effort shall include a feasibility study for scaling the design for applications from 250 W to 2 kW. Technology drivers are size, weight, and cost.

PHASE II: PHASE II: Using the Phase I design, the contractor shall develop and fabricate one (1) proof of concept Power electronics system. The contractor shall test the system under conditions that will verify component/subsystem readiness for integration on the 3 kW TQG.

PHASE III: PHASE III: The results from the Phase II effort will afford the contractor the capability to provide US Army and the DOD a new advanced state-of-the-art power electronics system for 250 to 3000 Watt power sources. The resulting key power electronics components can be transitioned into the commercial diesel power generating market, with potential applications in the automotive and marine markets as well. These components can also be transitioned to other diesel powered equipment within the Army’s inventory including other TQGs and the AMMPS family of generators as well as diesel powered vehicles.

REFERENCES:
1. Pamphlet 525-66, Military Operations - Force Operating Capabilities (www.tradoc.army.mil/TPUBS/pams/p525-66.pdf)

2. Army Regulation 70-38, Research, Development, Test And Evaluation Of Material For Extreme Climatic Conditions (www.army.mil/usapa/epubs/70_Series_Collection_1.html)

KEYWORDS: Nanotechnology, Power electronics, Generator Set

A10-097 TITLE: Enhanced Field Expedient Body Wearable Antenna

TECHNOLOGY AREAS: Sensors, Human Systems

OBJECTIVE: To develop a practicle Body Wearable Antenna or “Mantenna”, that will build on the design concept devised by Soldiers in theater for peer-to-peer communications, and make the antenna's performance equal or better than the exisitng large whip antennas worn by the soldier.

DESCRIPTION: The Mantenna overcomes problems encountered with the currently fielded 1 meter whip antenna, namely, its large visual signature and likelihood of entanglement with obstructions during Soldier maneuvers. Soldiers often fold this whip several times upon itself to avoid entanglement, but in doing so, eliminate its ability to support communications. These problems inspired Soldiers to develop and implement an in-field solution consisting of a ten foot section of coaxial cable, weaved in a serpentine fashion within the webbing on the back of the Improved Outer Tactical Vest (IOTV). This design unfortunately can only support single channel communications, due to its narrow bandwidth, and fifty to a hundred meters communications range, due to its low gain and unpredictable radiation pattern. Soldiers reported it was also cumbersome in connecting to the radio, due to its position on the back.

PHASE I: This SBIR Phase 1 proposal will focus on taking the Mantenna design concept and developing a body-wearable antenna system to increase its bandwidth, radiation performance and gain, ease of use, and improve its integration approach.

PHASE II: During Phase II the Mantenna will be developed further to increase its performance capabilities and integrate the design into an actual IOTV (improved outer tactical vest). The mantenna will be designed to operate as effectively as a baseline 1-meter whip antenna in the entire SINCGARS Radio Band (30-88MHz). The mantenna must have the capability to provide an easy to use, user adjustable functionality, to allow the mantenna to cover the entire SINCGARS band. The projected cost of the mantenna should fall within the current costs for the 1-meter whip. The installation of the mantenna into the vest shall not impede the protective capability of the vest. Three prototypes will be provided for government test and evaluation at government selected facilities. The government will perform SAR (specific absorption rate) testing to assure the safety of the soldier wearing the mantenna. Design considerations must be given to future manufacturability and installation into the vest.

Additional engineering development will further improve the design to allow the Mantenna to be completely integrated into the soldier combat uniform and function properly in the actual combat environment.

PHASE III: Further engineering design efforts will continue to develop the antenna system design further to include manufacturability and additional frequency bands of operation (i.e. EPLRS). Emphasis will be on improvements to SWap (size weight and power). Consideration will be given to integrate the mantenna into other soldier vests and/or soldier ensembles. The integration of the mantenna concept into clothing will have potential application in the non-military, commercial electronics market, as well as with firest responders (police and fire fighters) as well as in the construction industry.

KEYWORDS: mantenna, conformal, body-wearable, light weight, manpack radio

A10-098 TITLE: Adapterless Information Consolidation

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Soldiers currently end up with a multitude of information management interfaces after each successive technological advancement in the field of network management. These interfaces cause interoperability problems and require the use of adapters that can translate from one interface to another. A high number of adapters causes a network to be complex and also increases the total amount of time information takes to be get from one end to another due to the time it takes to process information at each intermediate node along a transmission path. There is a need to develop a solution that takes information from a variety of different sources and processes this information without the aid of adapters. The objective of this program is to develop a software engine that uses specified information about the domain space to automatically process any information from any data source without the need for developing any adapters.

DESCRIPTION: The standard solution to the Army's problem of incorporating and integrating different information from a variety of interfaces and data sources into a unified context and view consists of the development of specific adapters (for each source and interface) that format the data into a common API. This solution has a major problem where an adapter (software) needs to be developed for every new data source or interface; any subsequent changes to the API requires modifications (software changes) to all existing adapters.

Soldiers have a variety of data/information sources to deal with. Each of these sources have their own implementations in regard to precision, format, etc. and if they have a database, they'll have their own schema and data dictionary. Every application developer that wants to consume data/information from this eclectic set of sources has to understand and interpret each source application as a part of interfacing to the source to send and receive. Many developers perform the same complex tasks repeatedly, and make mistakes in the process. The developers then have to deal with updating the system when new sources are added, or some other situation develops that changes the behavior of the source application/database. Behavior of legacy and proprietary source applications/databases can, unfortunately, not be controlled. The disadvantages of this behavior can be mitigated, however, through a datastream transmission from the sources that have consistency, optimization, and stability such that the applications/databases need only one interface. Such an interface would reduce the need to do maintenance on every application/database when there is some sort of a change at the source end.

There is a need to develop a product that sits at some modest number of places in the network and takes in data/information from a reasonable variety of sources and puts them out in a form suitable for the creation of a "unified context and view." Such a product would eliminate the need for legacy data/information sources to be changed because the product will process the legacy data/information into a standardized form that is optimized for all of the applications/databases. If the results of this SBIR product prove successful, future data/information source applications can be then be required to put out their data/information in a format standardized by this SBIR program.

An optimized feed concept must be developed and all applications will have an API for that (so applications won't be hindered by many different data formats, etc. and there is no need to perform maintenance when a source is changed or a new one added). Processor middleware would sit on the network and receive the information that is not standardized, then convert the information into a standardized, optimally format. The information would then be outputed in its optimized format.

The advantage of this product is that the information/databases now get fed by an optimized, standardized, stream. Their schemas are simplified, the applications can share common databases, the possibility for "translation" error would be eliminated, and the need for applications to be updated to receive data/information from new sources is minimized or eliminated in some cases. The consistency across the data streams will result in the accomplishment of the goal of a "shared, common situational awareness" for Command and Control (C2).

PHASE I: Describe algorithms/techniques that can be used to consolidate information from a variety of interfaces and data sources into a unified context and view. The algorithms/techniques should eliminate the need for legacy data/information sources to be changed because the algorithms/techniques will process the legacy data/information into a standardized form that is optimized for all of the applications/databases. Bi-monthly status reports and final report should document progress made throughout program.

PHASE II: Deliver a software prototype based on algorithms/techniques developed during Phase 1. Final report should compare software prototype to products that existed prior to SBIR program, and document test results of software prototype. Target customers of software prototype should be identified in military and/or commercial industry. Acquisition program(s) should be targeted as military customers if software prototype is applicable for use within program(s).

PHASE III: The "end-state" result of this research would be integration of product into an acquisition program of record such as Program Manager-Warfighter Information Network-Tactical (PM WIN-T). This product is also applicable to application programs of record such as DCGS-A, CPOF as well as commercial network management systems. Integration in the military environment should result in an improvement in the consolidation of tactical network information into a unified context and view. Integration in the commercial environment should result in lower costs for organizations as they upgrade from one network management system to another and greater ease of management for commercial network administrators. Research should have a commercial application, or help enable one or more commercial technology products to be inserted into defense systems.

REFERENCES:

1. 'Automated Glue/Wrapper Code Generation in Integration of Distributed and Heterogeneous Software Components' by Wei Zhao, Barrett R. Bryant, Fei Cao, Carol C. Burt, Rajeev R. Raje, Andrew M. Olson, Mikhail Auguston

2. 'Leveraging Federal IT Investment With Service-Oriented Architecture' by Geoffrey Raines

3. 'Measuring Continuous Integration Capability' by Bas Vodde

4. https://ade.army.mil/learn/ADE%20Wiki/Architecture%20Overview%20-%20Interface%20Adapters.aspx

5. 'An Evaluation by SOA Frameworks' by Ramakrishna Raju

6. 'Design strategies for legacy system involvement in SOA solutions' by Jeremy Caine and Joe Hardman

7. 'Building an Integrated Ground Architecture to Respond to Present Challenges' by Pete Rustan

KEYWORDS: Service-oriented Architecture (SOA), Adapter, Integration, Translator, Netops, Application Programming Interface (API), Automation

A10-099 TITLE: Solid Hydrogen Fuel Cartridges

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: To provide a viable hydrogen source from solid fuels for use in portable fuel cells in order to decrease the weight burden of the soldier for extended missions.

DESCRIPTION: Power for the Dismounted Soldier is a persistent problem in current operations due to the growing amount of electronic equipment which must be carried by the individual soldier. Batteries, the traditional power solution, can serve to fulfill these power needs however for longer missions the weight in batteries which must be carried can become cumbersome. Using the state of the art battery technology, the BA5390 would require a soldier to carry 21 lbs of batteries for a 72hr mission at 25W of continuous power. Fuel Cells can offer an alternative solution providing longer runtime and at a reduced weight as compared to carrying traditional batteries. An ideal fuel source for these fuel cell systems is hydrogen; however compressed hydrogen tanks do not meet Army Requirements in terms of weight and safety goals. Alternatively, a solid hydrogen cartridge solution which could deliver a pure hydrogen stream on demand at a controlled flow rate, to the fuel cell system would be a viable solution to the growing energy problem. While some headway has been made in ability to produce hydrogen from solid fuels, a key issue in this development has been removing harmful contaminants from the hydrogen stream to prevent fuel cell stack damage. Specific design goals are for man transportable hydrogen sources with gravimetric and volumetric storage densities significantly greater than 4% by weight and 20 g/H2/L respectively. Transportation, operational safety and disposal, are critical factors in the technology selection process. Design goal priorities are safety, gravimetric and volumetric densities. The hydrogen source should be designed to be integrated with a 20-300 W fuel cell and operate in military environments including: Temperature (-20°C to 50°C), Altitude (up to 6,000 ft), Relative Humidity (0-95% not-submersed) and in sand/dust environments

PHASE I: Identify and describe fuel source. Conduct feasibility studies, handling/transportation safety analysis and technical analysis. Analysis should include information on safety, theoretical yield H2, achievable yield H2, cartridge design and ability to provide on-demand H2 at high purity level. Demonstrate feasibility of proposed technology. A first generation prototype demonstration is desired (not required) at the completion of the Phase I effort.

PHASE II: Phase II effort will focus on implementing and demonstrating the proposed design and integrating the hydrogen cartridge with a 20-300W fuel cell to demonstrate the technology at a minimum of a TRL 4 level. Integrated system should meet key Army Parameters for weight, temperature, safety. Multiple prototypes will be built and evaluated. A study of weight savings over traditional sources should be completed. Cost analysis should be performed.

PHASE III: This phase should focus one further advancing the technology so it suitable for operating in a military environment and passes all relevant MILSTD810. Potential military applications are soldier portable power and battery charging systems, etc. The most likely path for transition of this technology would be through direct sales of “alpha” units (low quantity) to organizations such as USSOCOM, and the Rapid Equipping Force. After successful demonstration, the most likely path for sales of higher quantities would be through direct marketing to organizations such as PM-Soldier Warrior and the program office for Future Combat Systems. Another path would be participation in an Army Technology Objective program with CERDEC to militarize the technology and transition to the organizations above.

REFERENCES:
1. Hamlen, Robert and Nycz, Thomas; Alternative Fuels for Military Portable Power; XCECOM; June 2009.

KEYWORDS: Fuel Cell, Hydrogen, Energy Storage, Lightweight Power, Polymer Electrolyte Membrane

A10-100 TITLE: Standoff-Biometric for Non-Cooperative Moving Subjects

TECHNOLOGY AREAS: Information Systems, 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: A compact biometric data capture system suitable for acquiring high quality facial recognition data over a long-range (100m-200m) of moving subjects, 24-7 and supporting both automated embedded recognition against a watch list and 3D facial model construction for data suitable for comparisons against large databases.

DESCRIPTION: Existing biometric systems work well on cooperative subjects in environmentally controlled settings in close proximity to the data capture systems. These systems require the subjects to have close proximity with the imaging systems and do not work well on non-cooperative subjects.
In order to capture data suitable for biometric identification at a standoff distance of non-cooperative and moving subjects under variable environmental conditions, a high level of system integration is necessary. This system will integrate optics, imaging sensors, and data processing to provide resulting images of the resolution necessary for biometric identification. The system must address issues of atmospheric blur, low ambient light effects, and motion blur. For tactical use, intelligence gathering, and force-protection operations, research and development are needed that will result in a robust standoff biometrics capability. The resulting systems need to operate at ranges long enough to provide response time for force protection and to enable covert surveillance. The resulting system must work across significant variations in pose and illumination, be portable, and work on battery power.
For force protection operations, working at checkpoints or base access points, the system should interface with existing fielded biometric systems. The system must support real time data collection of subjects moving through a choke-point at a natural walking pace. Data captured will be 3-d facial models generated from a series of 2-d images, where the resulting models can be used for both automated recognition and human intelligence analysis.

For maximum checkpoint utility, real time analysis against databases is required. For intelligence and tactical usages, the system should have the ability to detect and record all faces that enter its field of view with an embedded recognition algorithm to generate potential alerts for a small watchlist of subjects.

PHASE I: Develop a system designed for standoff face-based biometrics for non-cooperative moving subjects. Prove basic feasibility of the key design elements, including sufficient image resolution under ambient-light conditions. It should demonstrate the ability to automatically recover 3D models from such sequences. Deliver a system design specification that documents the approach to be used in Phase II for development of the prototype system, including technology and commercialization issues.

PHASE II: Develop and produce a prototype to demonstrate full system functionality. Should be ruggedized and have a small, lightweight form factor. It should utilize Commercial Off-The-Shelf equipment to minimize follow-on production costs. It should be low power with the ability to use AC or DC power. It should be designed with a network environment in mind to allow for unattended operation. Development of such a capability would satisfy aspects of Sensors, Electronics and Electronic Warfare a DoD Critical Technology Area. The system should include software for direct interfacing to existing databases. The hardware and software prototype must be demonstrated and all documentation showing improvement of state-of-the-art technology must be delivered.

PHASE III: The Phase III effort involves developing the prototype system design from Phase II into a commercial system, integrating the system into existing biometric capture applications, and developing new applications based on the improved user interface allowed with supporting standoff non-cooperative subjects. Military applications include border patrol, access control, and airport security, as well as integration into the proposed ATO-R Bio-NODE. Commercial applications include physical security, where long range can be important and intelligent user interfaces, where the non-cooperative moving subjects limit current biometric system applications.

REFERENCES:
1. Choi, Junoh; Soehnel, Grant H.; Bagwell, Brett E.; Dixon, Kevin R.; Wick, David V., "Optical requirements with turbulence correction for long-range biometrics", in Optics and Photonics in Global Homeland Security V and Biometric Technology for Human Identification VI. Edited by Choi, Junoh; Soehnel, Grant H.; Bagwell, Brett E.; Dixon, Kevin R.; Wick, David V. Proceedings of the SPIE, Volume 7306, pp. 730622-730622-11 (2009).

2. Boult, Terrance and Scheirer, Walter. "Long-Range Facial Image Acquisition and Quality" in Handbook of Remote Biometrics for Surveillance and Security, Edited by Massimo Tistarelli, Stan Z. Li and Rama Chellappa, Springer, pp 169-192 (2009)

3. Yao, Yi, Abidi, Besma and Abidi, Mongi, "Quality Assessment and Restoration of Face Images in Long Range/High Zoom Video" in Face Biometrics for Personal Identification, p43-60 2007.

4. R. Gross, S. Baker, I. Matthews, T. Kanade, Face Recognition Across Pose and Illumination, Handbook of Face Recognition, Stan Z. Li and Anil K. Jain, ed., Springer-Verlag, June, 2004,

5. Blanz, V. and Vetter, T, "Face recognition based on fitting a 3D morphable model" IEEE Trans. PAMI(25), No. 9, September 2003, pp. 1063-1074.

6."Electro-Optics Handbook" (pdf). burle.com. p. 63. http://www.burle.com/cgi-bin/byteserver.pl/pdf/Electro_Optics.pdf.

7. Blanz, V, Face Recognition based on a 3D Morphable Model, IEEE Conference on Face and Gesture Recognition, pp 617-624, 2006.

KEYWORDS: Standoff biometrics, face-recognition, 3D face models, biometrics, fingerprint, long-range identification. Night-vision.

A10-101 TITLE: Repeatable Virtualization of Intelligence, Surveillance & Reconnaissance (ISR) System

Servers

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Objective is to research and propose innovative technologies and methods for implementing virtualization of numerous existing physical servers on to fewer servers and storage arrays, in order to perform the same force elements/commanders' tasks while occupying significantly less space, consuming less power, and, reducing cooling needs. The virtualization configuration is then to be applied to various modern/emerging/future, net-centric ISR (Intelligence, Surveillance & Reconnaissance) Programs of Record (POR) systems/environments such as Distributed Common Ground System (DCGS), Guardrail Common Sensor (GRCS), Aerial Common Sensor (ACS), and, Joint Unified Maritime Protection System (JUMPS).

DESCRIPTION: Optimization of virtualized infrastructures includes network configurations, server settings, virtual machine settings, storage area network (SAN) software interfaces and hardware connections, virtual machine placement, and other settings that can be adjusted in order to achieve the best performance. Existing servers need to be virtualized using various tools that allow these existing physical servers to be converted to virtual machines. This conversion process should not alter the software load of the original physical server. The specific tool(s) to be used will depend on data/information/images provided by the U.S. Army. Existing physical servers need to be consolidated on to a minimum number of servers using automated installation methodologies. This consolidated environment should be viewed using remote access protocols.

PHASE I: Research and develop innovative solutions to provide effective means of virtualizing numerous existing physical servers on to fewer servers and storage arrays. Solutions may leverage both innovative and mature technologies, techniques, algorithms and/or mathematical models. The result of Phase I must include the proposed technical approach, including requirements, usage scenarios and a prototype architecture. Establish the feasibility, including technical risks, of the proposed approach. Define the approach for relevant experimentation suitable for feasibility assessment of practical implementation of the technology.

PHASE II: Capture the specific operational scenarios within a government specified domain. Develop a prototype to demonstrate the capability of the system for use by the Army. The architecture for the technology and how it fits into the target environment architecture will be defined. The Phase II technology will be integrated in a lab or simulated environment with the characteristics of the target environment. Define and collect initial performance benchmarks to validate the technology.

PHASE III: The end state of this research should provide implemented solutions for the use in operational military environments. Army applications include use of the technology within components of military intelligence exploitation and analysis systems. Candidate Army transition programs include DCGS-A, GRCS, ACS, and, JUMPS. Similar needs exist in the other services, homeland defense, and intelligence agencies. Commercial opportunities for this technology exist in numerous business scenarios, such as banking and credit card management.

REFERENCES:
1. U.S. Joint Chiefs of Staff. Functional Concept for Battlespace Awareness. Washington, D.C.: U.S. Joint Chiefs of Staff, 31 October 2003.

2. TRADOC Pamphlet 525-66, "Military Operations Force Operating Capabilities," March 7, 2008.

3. JUMPS T&E Lab Configuration. (Uploaded in SITIS 4/26/10)

KEYWORDS: virtualization, servers, net-centric, ISR, automated installation, remote access

A10-102 TITLE: Low Cost High Assurance Separation Kernel

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To develop a low cost high assurance separation kernel for use in cross domain solutions (CDS) and virtualization environments.

DESCRIPTION: Two of the major problems that the Army faces are 1) how to securely share data across security domain boundaries and 2) how to keep networks and data secure in harsh environments. In both cases virtualization can be leveraged as a security solution, but the issue of cost, even if moderate, can greatly come into play. This research effort will be focused on developing a COTS high assurance separation kernel in order to remove the cost hurdle of such solutions.

Cross domain solutions (CDS) come in a number of forms but when broken down to their basic functions they are the information assurance devices that allow data to be transmitted between networks of different classification levels (e.g., Secret to Unclassified) or allow data at multiple levels of security to be simultaneous displayed and accessed on a host. The CDS community has relied upon operating systems such as Solaris with Trusted Extensions (previous Trusted Solaris) and SELinux as a basis for their platforms, meanwhile the security community has developed a number of virtualized environments/separation kernels that can take CDS to the next level of assurance. Numerous papers tout virtualization as a security technology that should be embraced in order to create data processing partitions where one can separate trusted applications from untrusted applications. In doing so, if an untrusted application is exploited there is no damage or risk to the trusted applications and data. The virtual machine and hypervisor technologies can provide the separation and reference monitors needed to reduce the impact of software vulnerabilities.

Up until today the CDS community has relied upon medium assurance level operating systems such as SELinux, VM Ware, and Solaris (basis of systems such as High Assurance Platform (HAP) and DoDIIS Trusted Workstation (DTW)) to provide the base platform upon which to develop their security protections required of a cross domain solution, but as our enemies become more sophisticated and CDS become more prevalent through the Battlefield the medium assurance solutions may not be enough.

Therefore, the focus of this research would be to develop a COTS Separation Kernel that can meet the U.S. Government Protection Profile for Separation Kernels in Environments Requiring High Robustness and Evaluation Assurance Level (EAL) 5, 6, or 7 requirements for high assurance operations. The high assurance separation kernel will provide increased security, assurance, and robustness over the medium assurance operating systems used which would allow for an easier and faster certification and accreditation of CDS products, and an increased trust associated to the CDS product which would help in attaining type accreditations instead of site accreditations and support functions such as remote management. This would lower both research and development costs and supportability costs to the end Warfighter.

Additional research to be conducted under this topic includes how to host multi-level security (MLS) systems on top of a multiple independent levels of security (MILS) system using a high assurance separation kernel as a foundation. Also, with a lower cost alternative the high assurance separation kernels may find additional markets in tactical radios, network encryptors, UAVs, safety critical systems, embedded systems, software based encryption, etc.

Research areas of interest include but are not limited to: (1) virtualized environment security, (2) controlled information flow, (3) monitored inter-partition communications, (4) mandatory access controls, (5) reference monitors, (6) semi-formal and formal analysis and modeling, (7) memory management, (8) hardware partitioning, (9) least privileges, (10) assured data labeling, (11) multiple levels of security (MLS) and multiple independent levels of security (MILS), (12) trusted paths, subsystems, and I/O, (13) secure audit, (14) remote management and access, and (15) high assurance encryption through software.

PHASE I: Phase I will require an analysis of current high assurance operating systems, the separation kernel protection profile, and the EAL 5, 6, and 7 requirements. This analysis should lead into a certifiable separation kernel architecture.

PHASE II: Phase II will include the software development of the low cost high assurance separation kernel as well as an analysis of how to minimize the cost for a single license as well as bulk licenses for the separation kernel. Additionally, the Phase II effort should support running the high assurance separation kernel as the main operating system on a workstation as well as support embedded system use. The high assurance separation kernel should support running on x86 and Power PC architectures. The high assurance separation kernel should support running Windows XP, Windows Vista, Windows 7, Unix, and various flavors of Linux on top of it. The Phase II effort should also begin the analysis of how to complete and support a semi-formal or formal analysis of the separation kernel in support of an EAL 5, 6, or 7 certification. Additionally, an analysis should be done under Phase II to determine how to incorporate DO-178B "Software Considerations in Airborne Systems and Equipment Certification" requirements. The final effort under Phase II would be to demonstrate the system.

PHASE III: Developing a COTS separation kernel would be marketable to both DoD and commercial sectors. It would allow the DoD to lower costs of developing high assurance cross domain solutions and implement virtualized environments as security measures. Meanwhile the commercial domain would be able to leverage the technology to more securely separate networks based upon user's need-to-know (e.g., lower the risk of malicious software in the billing department to affect systems in the personnel department).

REFERENCES:
1. John Rushby, "The Design and Verification of Secure Systems," Eighth ACM Symposium on Operating System Principles, pp. 12-21, Asilomar, CA, December 1981. (ACM Operating Systems Review, Vol. 15, No. 5)

2. Information Assurance Directorate, National Security Agency, Fort George G. Meade, MD. "U.S. Government Protection Profile for Separation Kernels in Environments Requiring High Robustness," Version 1.03, June 2007 http://www.niap-ccevs.org/cc-scheme/pp/id/pp_skpp_hr_v1.03

3. "Common Criteria for Information Technology Security Evaluation," Version 3.1, CCMB-2006-09-001, 002, 003, September 2006

4. "MILS: High-Assurance Security at Affordable Costs", by Joe Jacob, Objective Interface Systems. November 2005. http://www.cotsjournalonline.com/home/article.php?id=100423&pg=2

5. "Secure Virtualization – Virtualization Congerges with Security for Bright New Future", by George L. Heron, McAfee Inc., October 24, 2007.

6. "DO-178B", http://en.wikipedia.org/wiki/DO-178B

7. DeLong, Rance. "MLS with MILS?", Center for Advanced Study Practice of Information Assurance, Santa Clara University. http://cisr.nps.edu/downloads/invlect/delong.pdf

KEYWORDS: Separation kernel, operating system, high assurance, COTS, cyber security, cyber defense, virtualization

A10-103 TITLE: Integrated Counter-Mine/Improvised Explosive Device (IED) and Command and Control (C2) Capabilities

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this topic is to develop and improve current state of RF technology, specifically in the area of wideband active noise cancellation to achieve electromagnetic compatibility (EMC) between multiple friendly RF systems including Blue Force Communications and Counter IED RF Jammers. The final goal is to develop such technologies which will realize the single RF system with dual functionalities of Electronic Warfare and Communication system.

DESCRIPTION: Fielding of Counter IED jammer system on individual tactical vehicle has caused electronic fratricides. This electromagnetic interference between friendly EW and Communication systems, and its inadvertent impact on their operations has been well documented and reported through USCENTCOM and other field commands in forms of JUONS and ONS.

As a short term mitigation of this problems, often times, there are temporary hardware quick-fixes that are designed which are suitable for the specific operating conditions of the system. However, the target for these temporary hardware fixes change often, necessitating a redesign as soon as the operating conditions change or new threats emerge. The goal of this proposed effort is to develop an funder mental enabling technology called active interference cancellation which enables simultaneous Jamming and Communicating capability where the functionality and Jamming-Communicating capability is not impaired by changes in the threat conditions and operating environment. The technical solution relies on using digital techniques for the implementation of the cancellation system. Central to wideband active cancellation techniques is the implementation of a correlator section, so as to determine the correct cancellation vector of the required band. This work proposes to develop and demonstrate such a system in phased approach.

PHASE I: The goal of Phase I is to develop and demonstrate the concept model. This work is targeted to implement the digital architecture necessary to realize the prototype of the interference cancellation unit. This phase will result in the delivery of a document detailing the results obtained and recommendations to proceed with the implementation of the demonstrator model.

PHASE II: The goal of Phase II would be to mature the concept model so as to produce the demonstration model. This stage would include extensive modeling and simulation work to better capture the specs used to define the design boundaries of the demo unit. The goal of this phase is to package the demo-model into a ruggedized suitable enclosure for demonstrations in lab/field tests.

PHASE III: The goal of phase III is to mature the demonstration model, incorporate extensive modeling, simulation and measured data obtained from phases I and II and incorporate modifications necessary to meet the requirements for volume production.

REFERENCES:
1. Common Timing and Electromagnetic Compatibility: Blue Force Comms/Video/Data Compatibility, Whitepaper, COBHAM Systems, May 15 2009.

2. C0-site and Jammer Interference Mitigation Using Optical Signal Processing, MagiQ technologies Company, Jan 2009

3. Optical Interference Cancellation for Broadband Radio-Frequency Communications, Lightwave Communications Research Laboratory, Princeton University

KEYWORDS: Cognitive Radios, Dynamic Spectrum Access, Frequency Hopping, Probabilistic Transmission, Interference Constraints, Cost Metrics, Bit Error Rate, Software Defined Radio, Electronic Warfare, Improvised Explosive Device

A10-104 TITLE: Human Signature Collection and Exploitation via Stand-Off Non-Cooperative Sensing

TECHNOLOGY AREAS: Sensors, Electronics, Human Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this topic is to develop thermal imaging technologies which will support the sensing, processing, analysis and exploitation of signature data based upon one or more intrinsic physical and/or behavioral traits of human beings for determination of hostile intent or stress in, and positive identification of, human beings, at reasonable stand-off distances and with day or night operation capability.

DESCRIPTION: The Human Signature Collection and Exploitation (HSC&E) mission area has application across all branches of DoD and the Army. It includes but goes well beyond traditional cooperative Biometrics, which has as its appropriately all-consuming mission the verification of identity of individuals for such applications as access control or forensics. HSC&E responds to the challenge of warfare among the people, where combatants are mixed in with civilians. Current tactical missions must deal with non-cooperative subjects at stand-off, detecting humans in clutter, recognizing them as having been seen before or belong to recognized social groups and what activities they are performing and whether these are benign or threat behaviors, characterizing them as to their health and well-being, emotional state or intent, identifying them by association with existent data bases, and tracking them individually but also as elements of more complex group activities and motion. Below, several examples are discussed to help guide the offeror. These instances should not be taken as limiting the offeror to these specific feature vectors, but rather as examples that demonstrate that these capabilities are achievable.

It is essential to be able to discriminate between enemy combatants and neutrals/friendlies. It has been demonstrated that active sensors are capable of differentiating between hostiles and neutrals. The canonical example is the Army Ghost laser system that is used in the defense of convoys, for which the inventors received the Department of the Army (DA) Research and Development Achievement (RDA) Award. Civilian vehicles are warned off by illuminating the vehicle windshield with green laser light, making driving extremely difficult. Only aggressive or hostile drivers continue to approach the convoy. Thus, hostiles are differentiated from neutrals, and appropriate action can be taken. Recent research has also demonstrated that passive thermal imagers are capable of detecting stress in individuals. Krzywicki et al has recently published work on the relationship between facial thermal signatures and underlying physiological stress.

It is also well known that exploitation of the thermal minutia present in the human face provides a robust feature vector and associated identification template. The National Institute of Science and Technology has explored several of these tools, and the results are discussed under the NIST Advanced Technology Program.
Thus, the primary purpose of this effort is to develop passive thermal imaging systems that can sense humans and collect both time dependent data that is indicative of heightened stress, anxiety, or other salient physiological cues to aggression or hostile intent, and time independent data that can be exploited as the basis for non-cooperative biometric identification, at reasonable stand-off distances and capable of day or night operation. An essential part of this effort will be the development of novel algorithms that are capable of extracting both the time-variant and time-invariant feature vectors from the matched thermal imager data stream.

Technology Challenges -
Development of passive sensors for the overt and/or covert collection of human signature phenomenology in any part of the electromagnetic or field strength spectrum. These sensors are to be designed and configured to collect these signatures at ranges and in environments appropriate to human activity such as urban and rural environments or in the areas surrounding forward operating bases. They must be designed and configured with the need for affordability foremost.
Development of data reduction and information discovery tools, such as but certainly not limited non-linear dimensional reduction algorithms and optical flow analysis.

PHASE I: The goals of Phase I are to:
- Develop the plan for the complete multiphase effort;
- Select candidate thermal sensor technology.
- Select candidate human signature feature vector for hostile intent/stress, including associated metrics.
- Select candidate feature vector for identification, including associated metrics.
- Model and demonstrate initial extraction of the above feature vectors from a multi-person data set. Data set not required to be collected under Phase I if publicly available or already a company asset.
- Model the performance of the candidate sensor as a function of range up to 100 meters, and ambient illumination (must be capable of day/night operation).
- Generate candidate matching template on the basis of the selected feature vectors.
- Provide detailed report on Phase I effort.

PHASE II: The goals of Phase II are to:
- Design, build, and demonstrate the performance of the thermal sensor system.
- Design, build, and demonstrate the software required to extract the feature vectors.

- Design, build, and demonstrate the software necessary to generate the matching template.
- Design, build, and demonstrate sensor fusion structures, data reduction and information discovery algorithms, collection, processing, or fusion enabling technologies to enable near real time operation.
- Integrate sensor system and software.
- Collect a multi-person data set with sensor system.
- Demonstrate determination of hostile intent/stress. Generate associated receiver operation characteristic (ROC) curves.
- Demonstrate determination of identification. Generate associated receiver operation characteristic (ROC) curves.
- Deliver operational sensor and software.
- Provide detailed report on Phase II.

PHASE III: The goals of Phase III are to:
- Mature the technical design for field demonstration.
- Design and implement interface with Army Intel Enterprise-compliant Biometrics Enabled Intelligence (BEI) framework being developed under CERDEC ATO(R) Biometrics – Non-Cooperatively Obtained Data and Exploitation (Bio-NODE).
- Collect a multi-person data set with mature system, at ranges that exceed 30 meters and under both day and night operation.
- Demonstrate determination of hostile intent/stress. Generate associated receiver operation characteristic (ROC) curves.
- Demonstrate determination of identification. Generate associated receiver operation characteristic (ROC) curves.
- Deliver operational sensor and software.
- Provide detailed report on Phase III.

Compliance and interface with ATO(R) Bio-NODE will enable transition to PM DCGS-A, JPI ICDT and PM Biometrics. Dual use includes application to challenges as are being addressed under the DHS FAST and the IARPA BEST programs and stress mitigation studies under Army Medical Research and Materiel Command, G3/5/7.

REFERENCES:
1. Antony, R.T. and Karakowski, J.A., 2008, “First-Principle Approach to Functionally Decomposing the JDL Fusion Model: Emphasis on Soft Target Data,” Proc. 11th Internat. Conf. Information Fusion, IEEE. Atran, S., 2008a, Who Becomes a Terrorist Today, Perspectives on Terrorism, Vol. II, Issue 5.

2. Atran, S., 2008b, The Making a Terrorist: A Need for Understanding from the Field. Testimony before the House Appropriations Subcommittee on Homeland Security, Washington, DC, March 12, 2008.

3. USAASC Website – Ghost - http://www.usaasc.info/alt_online/article.cfm?iID=0811&aid=04

4. Blechko, A., Darker, I.T., Gale, A.G., 2009, The Role of Emotion Recognition from Non-Verbal Behavior in Detection of Concealed Firearm Carrying, Proc. Human Factors and Ergonomics Soc. 53rd Annual Meeting-2009, 1363–1367.

5. Bossé, E., Roy, J., and Wark, S., 2007, Concepts, Models, and Tools for Information Fusion, ARTech House, Boston.

6. Diego A. Socolinsky, Andrea Selinger and Joshua D. Neuheisel, 2003, “Face recognition with visible and thermal infrared imagery,” Computer Vision and Image Understanding, Volume 91, Issues 1-2, July-August 2003, Pages 72-114, Special Issue on Face Recognition.

7. DTIC Search Engine: http://www.dtic.mil/

8. Ekman, P., and Friesen, W., 1978, Facial Action Coding System: A Technique for the Measurement of Facial Movement. Consulting Psychologists Press, Palo Alto, 1978. See also http://en.wikipedia.org/wiki/Facial_Action_Coding_System.

9. Jones, F. and Bright, J., 2001, Stress: Myth, Theory and Research, Prentice Hall

10. Advanced Technology Program NIST http://jazz.nist.gov/atpcf/prjbriefs/prjbrief.cfm?ProjectNumber=00-00-5680

11. Kulic, D. and Croft, D. 2005, “Anxiety detection during human robot interaction,” Proceedings of the 2005 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2005), pp. 616-621.

12. SENSIAC Military Sensing Information Analysis Center: http://www.sensiac.gatech.edu/

13. SPIE - Conferences & Publications on Photonics, Optics, & Imaging: http://www.spie.org/

14. Steinberg, A.N., Bowman, C.L., and White, F.E., 1999, “Revisions to the JDL Model”, Joint NATO/IRIS Conference Proceedings, Quebec, October, 1998 and Sensor Fusion: Architectures, Algorithms, and Applications, Proceedings of the SPIE, Vol. 3719.

15. US Army Night Vision and Electronic Sensors Directorate http//www.nvl.army.mil/index_main.php/

16. Krzywicki, A. T., He, G., O’Kane, B. L., “Analysis of facial thermal variations in response to emotion: eliciting film clips,“Proc. SPIE, Vol. 7343, pp-pp (2009)

KEYWORDS: sensors, human signatures, biometrics, thermal, imagery, algorithms, EO/IR, modeling, facial recognition

A10-105 TITLE: Heuristic-based Prognostic and Diagnostic Methods to Enhance Intelligent Power Management for Tactical Electric Power Generator Sets

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Establish an innovative approach for and demonstrate methodology and modeling tools to provide prognostics and diagnostics for use on tactical electric power systems (5 kW - 200 kW) and that complement the Army’s Hybrid Intelligent Power Management Program goals to increase system reliability and reduce fuel consumption on the tactical battlefield.

DESCRIPTION: Current Joint Operations in the Middle East have highlighted the need for increased system reliability and reduced petroleum consumption as both a cost reduction and force protection mechanism in the tactical battlefield. Real time estimates suggest that fielded Army generator sets consume up to 50% of the total fuel supplies at tactical units and forward operating bases in Iraq. To reduce system down time, fuel consumption, and the quantity of Class III (petroleum) convoys through volatile, high risk areas, the Army seeks diagnostics and prognostics techniques and solutions that can be applied to tactical generator sets in the 5 - 200 kW range. Resulting diagnostic/prognostic methodologies and techniques must be complementary with the Army’s Hybrid Intelligent Power (HIPOWER) goals.

The traditional approach of performing prognostics and diagnostics for mechanical plants has been to create a physics-based model based on first principles and known equipment characteristics. Such models are often created at the component level so that details of component performance can be captured. Component models like this can incorporate reliability from the material level up through components, sub-assemblies, and throughout the entire system. The second method, which is in many ways a derivative of the first, is to create a model from observed values and performance. Once a model is developed, regardless of basis, actual performance can be compared to the predicted performance with some level of diagnostics being reported if there are differences between the two. Both of these methods are capable of capturing failures that are caused by fatigue, thermal stress, corrosion, erosion and other forms of degradation. They can also address issues of uncertainty or variability in manufacturing, materials, maintenance history and usage history. This type of approach has been very successful in the airline industry.

The development of first principles or heuristic models to capture generator performance is another approach which can help to reduce fuel consumption rates of power systems and increase system reliability. While the approach can be cost prohibitive and requires multiple models to be developed for each size and vintage of generator set in the DOD Inventory, a Heuristic Model would allow the user to address a variety of diverse battlefield applications. Similar cost and diverse application issues are found in applying diagnostic/prognostics in buildings. For example, very few buildings have a common footprint and those that do almost never have similar mechanical plants or occupancy profiles. Even with such diversification, the building industry incorporates use of quantitative, reliable and accurate methods of diagnosing the performance of buildings. These techniques often provide a high rate of return on investments - quantified in terms of increased energy efficiency, reliability, and human comfort.

The goal of this SBIR is to define and develop innovative diagnostic/prognostic methodologies, techniques, software, and modeling tools for predicting tactical generator set performance and to provide a first order diagnostics and prognostics methodology for demonstration on a DoD Generator Set. The diagnostics methodology can be developed using first principles or heuristics models. Other methods built on Bayesian models, such as reinforced learning and non-classical approaches, such as genetic algorithms which treat the system like a biological organism subject to evolution due to multiple paths forward, the optimal being selected , will also be considered. The latter example has been used to optimize power inverters. Creative diagnostics methodologies that consider a "top-down" approach are encouraged. The method should be able to identify long-term generator performance degradation.

PHASE I: Design a concept for the required computational tools to accurately determine the reliability of generator sets. 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 shall consider the scalability (application to 5 kW – 200 kW Tactical Electric power sources) of this methodology. Focus shall be to reduce system down time and fuel consumption rates.

PHASE II: Develop, demonstrate and validate the methodology, connections and apparatus required to integrate the tools identified in Phase I to predict the reliability of a 10 kW Tactical Electric Quiet (TQG) generator set or a number of its sub-systems. Demonstrate the completed methodology and tools for predicting reliability on examples ranging from components through entire generator systems. In addition, validate that the methodology and tools can predict different failure modes for generator fleet. Validate the predictions using measured system data, preferably remotely sensed.

PHASE III: The main effort of phase III will be to transition the newly developed technology to a manufacturer, militarization, and qualification of the new application for the soldier. This technology could be used by various platforms and systems to improve their power management and thereby reduce their power use. The tools and methodologies developed could allow for the prognostics and diagnostics of other military systems.

POTENTIAL for COMMERCIALIZATION: There is a potential to transition this technology not only in the military sector but also in the commercial sector. In the commercial arena, hospitals, construction companies, power plants (hydro, nuclear, etc) and building management companies could use this technology to properly diagnose and maintain their power systems, correlating predicted performance with actual performance and modifying the heuristic algorithms as needed to extend component and system life. The advantages of using this technology in the military and commercial arena are lower repair costs, less downtime and improved longevity of power systems.

REFERENCES:
1. Haberl, J.S. and Abbas, M., 1998. "Development of Graphical Indices for Viewing building Energy Data," ASME Journal of Solar Energy Engineering, Vol. 120, pp. 156-161.

2. DOE 1997, International Performance Measurement and Verification Protocol, US Department of Energy, DOE/EE-0157

3. Haves, P., D.R. Jorgensen, T.I. Salsbury and A.L. Dexter. 1996. "Development and Testing of a Prototype Tool for HVAC Control System Commissioning," ASHRAE Transactions, Vol. 102, Pt 1.

4. ASHRAE, 1996, Fault Detection and Diagnosis for HVAC Systems, ASHRAE Technical Data Bulletin, Vol. 12, No. 2.

5. Zbigniew Michalewicz, Genetic Algorithms + Data Structures = Evolution Programs, Springer Verlag, New York, 1996

KEYWORDS: Reliability, Scalability, Prognostics, Diagnostics, Fault Detection

A10-106 TITLE: Modeling of concrete failure under blast and fragment loading

TECHNOLOGY AREAS: Materials/Processes, Weapons

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

OBJECTIVE: Develop analytical algorithms and numerical methods for the prediction of the structural response of concrete structures subjected to blast and fragment loading.

DESCRIPTION: There is a great interest in the defense community and in particular the U.S. Army Engineer Research and Development Center, Ref 1, in formulating theories and computational algorithms, which enable the accurate assessment of blast effects and fragment impacts on various types of concrete structures. These events are extremely complex and are relevant to a wide range of time and length scales. Novel multi-scale, multi-physics approaches in concrete modeling have shown great potential for simulating cracking and post-failure behavior of cementitious materials and, in general, quasi-brittle materials under a variety of loading conditions. The Lattice Discrete Particle Model (Ref. 2) has been demonstrated to be very suitable for simulating the fracturing process of conventional concrete and its post-failure behavior in a variety of loading conditions. However, many recent applications require the use of special concretes, such as Very High Strength Concrete (VHSC), Fiber Reinforced Concrete (FRC), etc. The modeling of these materials presents many challenges, because the scale of the aggregate can be very small and fiber-concrete interaction is very complex. Preliminary efforts in this area at ERDC have indicated that substantial effort needs to be placed in developing adequate analytical models for simulating the structural response of components made with these advanced materials.

PHASE I: Assess computational models for simulating VHSC, FRC, and other types of special concrete materials and cementitious composites in the context of a multi-scale, multi-physics, LDPM (Lattice Discrete Particle Model) framework. Identify shortcoming of current methodology and formulate a development strategy for future development. Characterize risk and potential payback of proposed modeling techniques. Perform some preliminary studies to compare the feasibility of new methodologies. Identify methods that should be implemented in a computational framework.

PHASE II: Implement methods identified in phase I in a computational framework. Improve efficiency of computational tools for the solution of very large problem on massively parallel computer systems implementing parallelization schemes. Improve robustness so that computational tools can be used reliably in a production environment.

PHASE III: Validate methods developed against experimental data. Application of the technology developed under phase II may benefit other areas in DOD as well as civilian agencies. Concrete materials are used in the construction of a variety of civilian structures, including bridges, dams, etc. Their response to extreme loading conditions is of extreme interest to the civil engineering community at large.

REFERENCES:
1. U.S. Army Engineer Research and Development Center (ERDC) Broad Agency Announcement, ERDC, Vicksburg, MS. http://www.mvk.usace.army.mil/contract/docs/BAA.pdf

2. G. Cusatis, A. Mencarelli, D. Pelessone, and J. T. Baylot. "Lattice Discrete Particle Model (LDPM) for Fracture Dynamics and Rate Effect in Concrete". Proceedings of the 2008 ASCE Structures Congress, April 24-26, 2008, Vancouver, Canada.

KEYWORDS: concrete, numerical methods, fracture, blast, multi-scale, multi-physics

A10-107 TITLE: Development of a user model and information system for multi-tiered approaches for modeling and predicting attributes of engineered nanomaterials

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: Development and design of an information system for mining data on the reported attributes for experimental engineered nanomaterials that have a potential for application in military technologies. This information system will be the foundation for a coupled approach to assess environmental attributes of engineered nanomaterials using both historical/reported data and existing models

DESCRIPTION: Many promising warfighter technologies are being developed through the Army's push in innovative research as emphasized in the Army S&T Plan, 2007. These new technologies are enabled through novel application of engineered nanomaterials. Engineered nanomaterials have unique properties due to their small size, 1 to 100 nm and a relatively high surface area. However, there is significant concern these unique attributes may be responsible for significant potential human health and environmental risks of nanomaterials. There are currently no tools available to predict or assess the risks of nanomaterials during development or during the life capability of the technology. These uncertainties and the lack of tools to address risk issues may delay or prevent the advances in warfighter technologies. Technical challenges for the prediction of environmental risks of engineered nanomaterials include (1) a lack of accepted measurement techniques and endpoints, (2) limited integration or use of data from published literature for predicting attributes of new materials, and (3) a lack of models to predict attributes. While some research and development will be required to develop models to predict behavior of nanoparticles in natural systems a user friendly information system of materials for academic, government, and industry research and development is highly desirable.

PHASE I: Development of a beta-version information system (wiki style) for mining new relevant data and information from published (peer reviewed, internet) studies into a usable source for materials scientists, biologists, and engineers. This information system should have capabilities for controlling access while maintaining the ability for users to readily access both the mined data and related references. The information system should have options for comparing measurement and attribute parameters including variability, analysis methods, endpoints, and qualitative information such as morphology. While it is not expected the beta-version have ready to use predictive models for attributes of nanomaterials, a conceptual approach and proposed models should be included.

PHASE II: Development of an integrated model and information system using all current data and information available to predict environmental attributes of engineered nanomaterials. Measurement parameters such as size, dispersivity, distribution, and charge should be included in measurement data options. Attributes such as degradation potential, fate in soils, toxicity, and bioaccumulation potential should be predicted from models and material attributes.

PHASE III: The product of this phase could find utility in the military and civilian communities. The model system should support military and civilian materials scientists and industry technology developers in understanding the environmental fate of relevant nano-compounds. This would augment acquisition analysis for the military relevant compounds and assist civilian developers in meeting TOSCA requirements. In addition, the system should have users in homeland security for assessing the potential attributes of agent threats enabled with engineered nanoparticles.

REFERENCES:

1. Army Environmental Policy Institute. 2005. How will army harness the potential of nanotechnology while ensuring compatibility with natural and human systems? Nov. 2005 issue. Ed1. 6pp.

2. Environmental Defense. 2005. Nanotechnology: EPA Crafting Nanotech Guide to Define 'New' Products subject to TSCA. Defense Environment Alert 13(26).

3. National Nanotechnology Initiative. 2008. Budget and Highlights. http://www.nano.gov/NNI_FY08_budget_summary-highlights.pdf. Last accessed on March 15, 2007.

4. Office of the Director, Environmental Programs (ODEP). 2007. FY07 Army Environmental Requirements and Technology Assessments (AERTA): Final Report. February 2007. Contract No. GS-10F-0076J, Order No. W911S0-04-F-0034. U.S. Army Environmental Command. Aberdeen Proving Ground, MD 21010-5401.

KEYWORDS: nanomaterials, classification system, chemical attributes, integration software

A10-108 TITLE: Developing Capabilities for the Visualization and Analysis of Qualitative Data within Geographic Information Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To develop the capabilities for visualizing and analyzing qualitative data within geographic information systems in support of counterinsurgency operations.

DESCRIPTION: With the evolution of counterinsurgency warfare, the modern battlespace has expanded into political, military, economic, social, informational, and infrastructural (PMESII) domains that were not the traditional focus of military analysis. Instead of considering entirely kinetic courses of action (COA), military leaders at every level must now consider how to best interpret intelligence coming from a wide range of sources in order to effectively account for PMESII factors in their COAs. It is widely regarded that many of the notable successes that have taken place in Iraq and Afghanistan were made possible by the proactive efforts made by coalition forces to understand and respect the local culture.

Naturally, this understanding requires the collection and analysis of nontraditional types of intelligence, which often take a qualitative, or non-numeric, form. However, as a whole the Army continues to rely heavily upon intelligence systems primarily structured to support quantitative data modeling, visualization, and analysis. For example, one of the primary software tools for geospatial analysis, the geographic information system (GIS), was originally developed exclusively for quantitative planning uses. A majority of the tools currently available in GIS applications operate exclusively on numerical data. Although many geographers in the academic world have begun to call for a 'rewiring' of GIS, none have offered a solution to date. This SBIR's objective is to design and build geospatial software to aid warfighters in the visualization and analysis of qualitative data. It aims to overcome several problems inherent in current geospatial solutions:

The first major problem in current GIS options is that they have difficulty with the direct storage and geovisualization of qualitative data. This problem stems from two primary causes. First, unlike quantitative data, which primarily takes a numerical or categorical value, qualitative data can take a wide variety of formats, including audio, interview transcripts, drawings, photographs, and videos. While users can currently hyperlink out from GIS to other programs which are capable of storing these data forms, users do not have direct access to this data from within the GIS itself. Hyperlinks detach data from their spatiality, defeating the purpose of geovisualization in the first place. For example, including user videos directly into a GIS might help warfighters identify behavioral spatial patterns that they may not have otherwise spotted.

Additionally, qualitative data is often abstract, relative, or not explicitly spatial, and the Cartesian framework in which GIS was developed has difficulty with this. GIS displays all features as concrete points, lines, or polygons, but real spaces are much fuzzier. They may be contested, uncertain, or emotionally charged, or they may even look different depending on the perspective with which they are viewed. For example, a GIS would have difficulty symbolizing the full complexity of a fight over claims to an area that is spiritually important for one community but usurped by an more powerful community that is using it for agriculture. This is further complicated by claims that may be temporal in nature (such as migratory claims to a space). GIS may also have difficulty with relationships that are not explicitly spatial, such as 1) ethnic and religious relationships between people or 2) relationships between a person and a space.

The second major problem stems directly from the first—because GIS has difficulty storing and visualizing qualitative data, it cannot effectively analyze this data. This flaw manifests itself in three ways. First, to overcome its deficiencies, GIS software forces users to simplify their qualitative data to a quantitative form. For example, a recent article shows how an Army S-3 (operations) officer had attempted to prioritize aid to Afghan villages based on their conditions. To accomplish this he collected qualitative data, such as current levels of public safety, support for coalition forces, and food security. Unfortunately, in order to analyze these qualitative measures the S-3 officer was forced to convert his data into very basic, ranked categories, and in the process rich details of the original data were lost. For example, does the category 'moderate support for coalition forces' mean that villagers 'will completely ignore warfighters' or that villagers 'will oppose warfighters unless the warfighters gain the support of village elders, at which point they will actively help the warfighters'? These two versions of 'moderate support' are impossible to rank against one another, as neither is clearly superior to the other, and they are only two gradations of the many forms of 'moderate support' possible. The only way to effectively utilize all the possible qualitative factors in play is through an analysis that doesn't force the factors into quantitative rankings or categories.

Secondly, the abstract, contested, and temporal factors which shape spaces are often excluded from analysis within GIS. These factors go into explaining why a certain space is what it is and why one group is claiming it, but GIS only shows what the space is and who currently controls it. 'Why' is incredibly important if warfighters expect to solve the root problems of an insurgency. By including all of these qualitative attributes in a GIS, users can begin to understand how social systems and networks interact spatially.

Finally, GIS has difficulty analyzing any type of relationship that is not explicitly spatial. Villages may be related to one another, not just by geographic distance, but through kinship, religion, or ethnicity. Similarly, abstract notions of religion or custom may affect migratory patterns more than terrain and distance alone. By acknowledging that not all relationships are exclusively spatial, GIS software could begin to leverage other types of analysis against its data, such as social network analysis or systems theory. Only then will warfighters begin to understand the complex interrelationships between PMESII domains and the spaces they inhabit.

An effective solution to these problems must be capable of both visualizing qualitative data and then analyzing it. The above description gives examples of some forms of qualitative data and analysis, which might be useful for warfighters. Additionally, it should accomplish these tasks while retaining the geospatial capabilities that make GIS such a powerful tool.

PHASE I: The contractor has two tasks in Phase I. First, the contractor needs to develop a preliminary software design capable of several tasks. The proposed software must be capable of geospatially visualizing multiple formats of qualitative data. It should also be capable of visualizing 'fuzzy' data sets, as described above. Additionally, the proposed software must be capable of analyzing complex qualitative data. The contractor must develop an approach of qualitative methods of analysis that would be useful for the warfighter; examples include social network analysis or the ranking task described above. This analytical approach should be included with the preliminary design with appropriate references to the literature. The GIS should be capable of analyzing contested spaces, temporal changes, how relationships that aren't explicitly spatial affect spaces, and the reasons why a space is as it is. It may attempt to bridge GIS and computer-aided qualitative analysis software (CAQDAS) capabilities in an integrated fashion.

Second, the contractor needs to develop a small prototype as proof of concept implementing one of the visualization tasks described above. This prototype should be a geographic information system capable of storing and visualizing basic qualitative data formats. This prototype will serve as proof of the contractor's technical suitability for designing the complete prototype.

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 explore each of the three criteria explored in Phase I. Testing will progress with data provided by the Government.

PHASE III: The SBIR will result in a technology with broad applications in both military and civil communities. The software will allow warfighters to visualize and analyze PMESII data that takes a qualitative form. This will give them a more intricate understanding of the insurgency they are fighting and the root causes of that insurgency. The intelligence community would also find a high amount of utility in the tool. Since there are few, if any, software platforms designed to perform geospatial analysis with qualitative data, intelligence officers could use the technology to analyze socio-cultural patterns within target populations or countries. The technology would also have direct applicability for many other civilian pursuits. Although there has been much interest in qualitative forms of geographic information systems in academic realms, there is still no commercially available software. Many sources confirm that this type of software would have great utility for grassroots political organizations attempting to enforce rights to various spaces of the city.

REFERENCES:
1. Gellman, CPT Brian. 2009. “Assessing Stability During COIN or Stability and Support Operations Through Patrol Debriefs.” Military Intelligence. January-March.

2. Gorkowski, CPT Justin. 2008. “Iraqi Non-Lethal Contributions to the Counterinsurgency.” Small Wars Journal. 20 April. http://smallwarsjournal.com/blog/journal/docs-temp/55-gorkowski.pdf

3. Jung, Jin-Kyu. 2009. “Computer-Aided Qualitative GIS: A software-level integration of qualitative research and GIS.” Qualitative GIS: A Mixed Methods Approach. Eds. Meghan Cope and Sarah Elwood. Los Angeles: Sage: 115-36.

4. Kipp, Jacob; Grau, Lester; Prinslow, Karl and CPT Don Smith. Sept-Oct 2006. “The Human Terrain System: A CORDS for the 21st Century.” Military Review. http://www.army.mil/professionalwriting/volumes/volume4/december_2006/12_06_2.html

5. Kwan, MP and Ding, G. 2008. “Geo-Narrative: Extending geographic information systems for narrative analysis in qualitative and mixed-method research.” The Professional Geographer, 60(4): 443-465.

6. Kwan, MP and Knigge, L. 2006. “Qualitative Research and GIS.” Environment and Planning A, 38(11): 1999-2002.

7. Marr, LTC Jack, et al. 2008. “Human Terrain Mapping: A Critical First Step to Winning the COIN Fight.” Military Review. March-April. http://usacac.army.mil/CAC2/MilitaryReview/Archives/English/MilitaryReview_20080430_art006.pdf

8. Sieber, RE. 2004. “Rewiring for a GIS/2.” Cartographica. 39(1): 25-39.

KEYWORDS: geographic information systems, qualitative data analysis, visualization

A10-109 TITLE: Sustainable Materials to Reduce Heat Signatures of Base Camps

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop materials and processes for use in sustainable military base camps to reduce heat signatures emanating from base camp through the use of advanced insulating materials in conjunction with thin-film thermoelectric generators and embedded batteries.

DESCRIPTION: Base camps require reduction in heat signature to maintain low-observable (or stealth) capabilities. Personnel and equipment within the base camps generate characteristic heat signatures that can reveal the location, presence of personnel and electronic equipment, and may provide some indication of activities and OPTEMPO.

However, future base camps must reduce their heat signature for both the warfighter and the sustainment force. Emerging materials will be used in military base camps construction in many different climates to reduce heat signatures through the use of high efficiency insulating materials and thermoelectric coolers, which synergistically reduce radiated heat. Solid state devices can be embedded in layered composite fabric that offer high stiffness/high strength to weight ratios and are durable in harsh environments, such as desert heat. Such devices can be used to reduce the infrared radiation emanating from personnel or critical electronic equipment, e.g., for Command, Control, Communications, Computers, Information, Surveillance, and Reconnaissance (C4ISR).

Thermoelectric Peltier devices can transfer heat from one side of the device to the other side against the temperature gradient (from cold to hot), with consumption of electrical energy. The power to drive the Peltier devices would be derived from the integrated photovoltaics on the top layer, or thin film batteries embedded into the composite structural material. The use of insulating composite fabric layers would help to insure thermal efficiency of the system. These relatively light-weight materials could reduce logistics burden of transporting heavy air conditioning (A/C) systems and the weight burden of deploying heavy electricity generators.

PHASE I: Conduct research on the materials and processes to integrate innovative solid state power supply and thermal signature management capability into materials for military base camps. For example, emerging thin film inexpensive polycrystalline silicon based photovoltaic devices and thin film batteries, or supercapacitors, along with thermoelectric devices and insulators could be embedded into composite layers of tent fabric to provide 2,500 watts of electric power for an enclosure of typically 200 cubic meters for solid state cooling devices and other equipment. Investigate the use of lightweight (~1.5 g/cc) layered composite fabric with high stiffness (e.g., 80 GPa) and strength (~ 3.5 GPa), for use in in multiple environments, which contain insulating layers to provide additional thermal management. The target heat dissipation goal is ~10,000 BTU/h. Predict the efficiency of the composite multifunctional materials for thermal signature reduction. Demonstrate the capabilities at the laboratory scale, and down-select the most promising technologies for further development. Although the light weight feature is desirable, it can be sacrificed if necessary to achieve the other multifunctionalities.

PHASE II: Design and test high strength lightweight multi-layered materials that for base camps shelters that protect personnel and equipment from inclement weather, high heat and humidity, and wind blown debris, which harness advanced embedded power systems to provide heat signature reduction on the surface of the base camp in military critical facilities, such as Command Control Communication, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) equipment and facilities. Develop manufacturing methods to produce these layered materials, with the approach of scaling up to full sized smart sustainable base camp construction materials

PHASE III: Commercialize multi-layered construction materials that incorporate power generating and thermal management components for use in both military and non-military buildings and structures, including industrial environments. It is anticipated that commercialization will be achieved through co-operative agreements between the SBIR Company and their partners as well as well-established maanufacturers of innovative fabric structures, thermo-electric coolers, and photovoltaic design and manufacturing companies. The resulting structural components would not only provide structural protection, but would also provide low observable capabilities. In addition, the materials would be readily portable and could be used for tents used by campers in multiple and diverse climates.

REFERENCES:
1. O. Kunz, Z. Ouyang, J.Wong, and A. G. Aberle1, “Advances in Evaporated Solid-Phase-Crystallized Poly-Si Thin-Film Solar Cells on Glass (EVA),”Advances in OptoElectronics, Article ID 532351, pp. 1-7, 2008.

2. Ji Yeong Lee, Kay Hyeok An Jeong Ku Heo, and Young Hee Lee, “Fabrication of Supercapacitor Electrodes Using Fluorinated Single-Walled Carbon Nanotubes,” J. Phys. Chem. B, 107 (34), pp 8812–8815, 2003.

3. Hu, Eric; Kaynak, Akif; Li, Yuncang, “Development of a cooling fabric from conducting fibers: proof of concept,” Synthetic Metals, Vol 150, 2, pp.139-143, 2005.

4. Dubi, Y., and M. Di Ventra, "Thermoelectric Effects in Nanoscale Junctions," Nanoletters 9 (1), pp. 97-101, 2009.

KEYWORDS: base camps, heat signature, photovoltaics, insulating layers, Peltier device

A10-110 TITLE: Development of a desktop application to integrate tools and databases for environmentally-important chemical aspects of military compounds

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: Integration of applications for predictive environmental chemistry with databases of environmentally-important physical/chemical properties to create a user-friendly desktop visualization and manipulation application for environmental computational chemistry

DESCRIPTION: The environmental fate and transport of compounds of military interest is a specialized area of research that combines predictive computational chemical tools with experimental verification to assess the impact of these compounds on lands overseen by the Army. Current research efforts have resulted in a body of data that includes physical/chemical properties of military munitions and their degradation products, such as solubility in water, octanol-water partition coefficient and Henry's Law constants. Quantitative Structure Property Relations (QSPRs) and Quantitative Structure Activity Relations (QSARs) have been developed to relate structures of military compounds to physical properties and to toxicity, respectively. Degradation pathways have been predicted for many military munitions and verified with benchtop experiments. Programs have been developed to predict water solubility of nitro-compounds with greater accuracy, and to integrate kinetic equations. A need exists for the integration of all of these components into a user-friendly desktop application that would allow one to access the environmental data, visualize it and manipulate it as needed. Key components to this desktop application would include 1) the ability to access the physical property database, 2) the ability to add new data easily to the application, 3) the ability to work with subsets of data to create new QSPR/QSAR relationships, 4) the ability to visualize data. As some of the datasets will be large, the ability to operate under a client/server model that could be launched from the desktop application would be desirable.

PHASE I: Development of a beta version wrapper to incorporate the available and relevant databases and stand-alone programs for physical property prediction that comprise this visualization and manipulation application. This wrapper should include both predicted and measured databases of physical properties as well as the ability to track and compile pertinent references. Significant emphasis will be placed on data pertaining to and visualization of nitroamine compounds, high nitrogen energetic compounds and some metallic species. ERDC researchers will supply a number of small applications that need to be incorporated into the desktop application such as a Windows-based program that solves the kinetic equations. We also have a basic molecular viewer that is Windows-based (this application allows us to view input directly from most common computational chemistry software). Starting from this capability, innovative ways to visualize data would be desired. ERDC will supply an application to generate new QSAR equations when such data is added to the database. Another aspect of this proposal should include the ability to provide a port to access outside computers to submit calculations, monitor results and pull results back to the database. Also, post-processing software to extract relevant information from software output would be needed. This application should be able to run from a desktop computer preferably with a Linux-like platform but with a minimum of Windows.

PHASE II: A fully integrated software application would be developed based on the beta wrapper developed in Phase I. This would include development of an expanded capability that allows for easy insertion and retrieval of data. Ability to visualize results and produce 2-D and 3-D plots of results. Ability to connect to a larger server to manipulate data and generate new data.

PHASE III: This project will result in a technology with broad applications in both the military and civil communities. The software will allow a unique capability to manipulate and visualize a significant amount physical property data concerning a chemical compound. This will provide a foundation for being about to visualize how chemical compounds react in various environments including the natural environment but extending also to anthropogenic (chemical R&D) and physiological environments (pharmaceutical industry).

REFERENCES:

1.Application of quantum-chemical approximations to environmental problems: Prediction of physical and chemical properties of TNT and related species Qasim Mohammad, Kholod, Yana, Gorb, Leonid, Magers, David, Honea, Patricia), Leszczynski, Jerzy . CHEMOSPHERE Volume: 69 Pages: 1144-1150 Published: 2007

2. Consensus QSAR Modeling of Phosphor-Containing Chiral ACNE Inhibitors. Kuz'min, Victor E., Muratov, Eugene N., Artemenko, Anatoly G., Varlamova, Ekaterina V.,Gorb, Leonid,Wang, Jing, Leszczynski, Jerzy.: QSAR & COMBINATORIAL SCIENCE Volume: 28 Issue: 6-7 Pages: 664-677 Published: 2009

3. Website for software to access from the proposed desktop application: http://www.msg.ameslab.gov/index.html

KEYWORDS: computational chemistry, visualization software, molecular dynamics

A10-111 TITLE: Non-rotating Wind Energy Generation

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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: Demonstrate an inconspicuous, non-rotating compact wind energy system with the capacity to produce up to 1.5kW of electricity with a suitable wind resource.

DESCRIPTION: Energy is an important priority for the Army. Electricity generation from wind turbines is growing worldwide, and mountainous, desert, and littoral theaters of operation often have excellent wind resources; however, wind turbines are highly visible, not tolerant to damage, and relatively difficult to transport and assemble. The U.S. Military has expressed concerns over installing wind turbines at military sites stating that, while DoD strongly supports wind energy, wind turbines located in a radar installation's line of sight might adversely impact the unit's ability to detect threats[1]. The military also has a need to utilize installations and forward operating base camps as power projection platforms[2]. The need to recharge batteries can be a limiting factor in mission capability. A modular wind energy system that is silent and inconspicuous would be of great value, but to date, such a system does not exist. An electro-kinetic approach to wind energy harvesting may be able to meet these requirements. Electro-kinetic systems are those in which electrostatic fields affect the motion of a charged medium. Commercialized examples in military applications include colloidal thrusters for ion space propulsion, and certain types of micro-fluidic systems for thermal management. This technology can also be applied to wind energy applications[3-5]. Although the scientific validity was shown in earlier work, viable commercial products were not pursued.

PHASE I: Evaluate electro-kinetic approaches to wind energy conversion, and identify candidate design and manufacturing methods capable of delivering 1.5-3kW of power with a wind resource of 10 meters per second. Evaluate the use of in-theater, recyclable or waste liquid working fluids for such systems, or possible use of condensates. Provide laboratory demonstration of technical feasibility and provide evidence that scale up to required power capacity is possible. Develop a conceptual design of a deployable system, with estimates of size, weight, cost, and manufacturability. The system must be designed to be contained within a volume of 9 cubic meters or less and have ground contact footprint of less than 9 square meters. The combined weight of the unit must not exceed 300 kg.

PHASE II: Design, construct, and evaluate a 1-2kW prototype wind energy system. Develop manufacturing plan and cost model. Demonstrate that the design size, weight and transportation requirements can be met. The design of the final prototype system must be capable of continuous power production at a sustained net power level of 10 watts or greater, DC or AC power, and into a 50 Ohm resistive (non-reactive) load. The power level must be in excess of any start up or maintenance power that may be required for the production of ion sources and any auxiliary pumps required for continuous operations. Such auxiliary start up or maintenance power requirements must not exceed a total of 20 Watts and it must be serviced by an on-board, self contained power source capable of being recharged to full operational levels once the system is in operation. The system must be capable of continuous, self-contained and sustained operation for a period 10 hours for sustained wind speeds in excess of 10 meters per second during that period. For speeds less than the stated minimum, the system must be able to enter and execute a safe auto shut down or stand-by mode if the required output power falls below 8 Watts. The system should contain a wind sensor capable of sampling and distinguishing if ambient wind speeds will be continuous and in excess of the required minimum for a period of at least 30 minutes. Failing this, the system should remain in a stand-by mode. The choice of fluids may be varied but must be capable of full performance with the unit for ambient temperatures ranging from 10 to 50 degrees Celsius, and at relative humidity ranging from between 5% to 85%, at the stated temperatures. Any fluid used in the production of the required power levels must be at a flow rate of less than 4 milliliters per minute. The system must run in a continuous operational mode and generate an integrated noise level of 85 dB or less.

PHASE III: Dual Use Applications: Modular, low cost wind energy systems will have applications in a variety of civilian settings including recreational, residential and distributed systems for commercial applications. High levels of interest in wind energy dictate a rapid commercialization potential.

REFERENCES:

1. Office of the Director of Defense Research and Engineering, "The Effect of Windmill Farms On Military Readiness – 2006," REPORT TO THE CONGRESSIONAL DEFENSE COMMITTEES.

2. U.S. Army Training and Doctrine Command, Military Operations Force Operating Capabilities, TRADOC Pamphlet 525-66.

3. Marks, A. "Wind Power Charged Aerosol Generator," Final Report Subcontract XH-9-S128-1, Solar Energy Research Institute (SERI) of DOE, 1980.

4. Minardi, J., Lawson. M., "Conceptual Design of an Electrofluid Dynamic Wind Energy System," SERI Final Report, SERI/STR-211-2277, DOE contract No. DE-AC02-83CH10093, 1984.

5. Bodega, R., Sonneveld, P.J., Morshuis, P.H.F., van Rooij, R., van Eldijk, L.G.M., "Conversion of wind into electrical energy without the need for moving parts," 13th Internal Symposium on High Voltage Engineering, Netherlands, 2003.

KEYWORDS: wind power, non-rotating, renewable, modular, electrostatic

A10-112 TITLE: Multiple Mode Structural Health Monitoring System for Equipment and Facilities

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop an integrated environmental sensing system to monitor environmental effects on critical military infrastructure and weapons component health.

DESCRIPTION: Mechanical and electrical systems in military infrastructure and equipment are susceptible to a wide variety of failure modes influenced by environment and use. There is a need for an extensible and universal monitoring system that is minimally intrusive and can be rapidly configured and deployed. These systems would be useful in monitoring corrosion, fatigue and other damage modes to reduce inspection and maintenance burdens. To maximize system versatility these smart systems should be based on IEEE interface standards and must be small, light weight and low cost. Significant on board processing capabilities will be needed for embedded diagnostics and prognostics. The systems should also be compatible with a wide variety of power storage or energy harvesting devices.

Specifically, integrating the data from sensors for atmospheric, pitting, and stress corrosion cracking can yield more relevant component health information than the individual sensor data could provide. Software integration can be tailored to utilize a more universal sensor to provide individual part health.

PHASE I: The phase I effort will provide a prototype demonstration of the multi-mode health sensor. The Sensor must be subject to short term accelerated corrosion as well as longer term exposure validation. The initial software design for sensor control, integration and analysis shall be done at this stage.

PHASE II: Once the brassboard prototype is developed, it must be further reduced in size and power consumption. In addition it must be appropriately hardened for field use while maintaining sensitivity and accuracy. Hardened sensor performance should be tracked against existing sensor technology across a wide variety of simulated corrosive environments at this stage.

PHASE III: The end state of this research will likely be fielding at critical DoD infrastructure nodes such as bridges and vertical structures. Petroleum Oils and Lubricants (POL) uses include sensing in harsh environments like tank sludge in storage tank bottoms. Other heavy users of corrosion sensors include the petrochemical and refining industries and the emerging bio-fuels sector. Matching funds should be sought from these sectors and others.

REFERENCES:
1. "A multi-point optical fibre sensor for condition monitoring in process water systems based on pattern recognition" Measurement Volume 34, Issue 4, December 2003, Pages 301-312, Elsevier, W. B. Lyonsa, H. Ewaldb, C. Flanagana and E. Lewis.

2. "A multi-criteria decision model to determine inspection intervals of condition monitoring based on delay time analysis" Reliability Engineering & System Safety Volume 94, Issue 5, May 2009, Pages 905-912 Elsevier, Rodrigo J.P. Ferreiraa, Adiel Teixeira de Almeidab, and Cristiano A.V. Cavalcanteb.

3. "In-situ process and condition monitoring of advanced fibre-reinforced composite materials using optical fibre sensors" C Doyle et al 1998 Smart Materials and Structures 7 145-158.

KEYWORDS: Corrosion, Material Degradation, Condition Sensor, Pitting Corrosion, Atmospheric Corrosion

A10-113 TITLE: Electronic Sensing Fiber Scaffold Sensor

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: Develop a sensing element that exhibits an electronic signal upon detection of a chemical or biological stimulus for incorporation into a textile-based conductive core fiber worn on the uniform in a patch-type application.

DESCRIPTION: The modern Warfighter lacks the ability to sense the existence of threats beyond the traditional sights and smells on the battlefield without the help of additional bulky equipment. The proposed research will provide the Warfighter with electrochemical signals from a chemical/biological sensing patch on the Warfighter’s uniform to greatly improve the Warfighter response time, survivability and lethality. Conventional high-sensitivity sensors are often too heavy and too expensive to be carried by all dismounted Warfighters. Incorporation of sensitive, low-power sensor elements into a fiber/textile material uniform patch capable of transmitting electronic signals through to a conductive core/channel to a lightweight readout device would allow each dismounted Warfighter the ability to identify and avoid potential battlefield threats.

Recent research has focused upon chemresistors and chemFETs as sensors for various chemical threats with varying degrees of success. Inorganic semiconductors, flexible and light conductive polymers, and specially treated carbon nanotubes are examples of designs that will be considered in the proposed research. It is envisioned that a single chemical chemresistor sensing element would be placed into a suitable high-throughput polymeric fiber spinning process to create a strand of one-time use indicator fiber. Additionally developed single chemical chemresistor sensing element fibers could then be bundled into a wearable patch to provide multi-chemical threat detection/specificity and result in substantial reductions in both cost and weight. To produce a sensor system, the sensing elements must be developed that can rapidly change their electronic properties upon exposure to a battlefield threat such as a toxic industrial chemical at sensitivity levels below the exposure threshold to the Warfighter, and transmit a signal to a conductive core fiber to provide an alert to the Warfighter.

The conductive core fiber research will attempt to maximize the available surface area for the chemresistor sensor while keeping the overall fiber diameter to a maximum of 100 microns. Appropriate fiber and chemresistor combinations will also be evaluated to ensure that signal conductivity in conditions are capable of spanning temperature ranges of –60 degrees F to +160 degrees F and humidity ranges of 0% to 100% Relative Humidity in order to simulate operating conditions encountered by the Warfighter. Additionally, the sensing molecule will be designed to exhibit sufficient mechanical robustness when incorporated into the conductive fiber of a uniform patch to survive the demands of textile operations and abrasion resistance. Specifically, as a uniform patch application, the conductive core fiber and chemresistor combination would not be required to pass laundering tests, but should be able to operate in situations such as rainstorms and other climatological battlefield conditions.

The fiber plus sensor element will be designed to detect Army relevant threat(s) and elicit a response to a challenge chemical in a reasonable timeframe to warn the Warfighter of the impending threat. The chemresistor design should also be capable of good selectivity to avoid triggering false positives. The chemresistor will respond to threats in the vapor phase (i.e. gas/vapor in the surrounding air). Limits of detectability are expected to vary with different chemical species; however, the chemresistor must elicit a positive response to a challenge at limits below levels considered a threat to the Warfighter.

PHASE I: Identify candidate chemresistor(s) or similar type sensor for detecting a CB relevant threat. Demonstrate incorporation of sensing element to a conductive fiber platform and electronic connection to fiber conduction method and show sensitivity to a laboratory threat environment. Mitigate risk by identifying and addressing the most challenging technical barriers in order to establish viability of the technology or process.

PHASE II: Refine the chemresistor sensor to reduce possibilities of false positives and fabricate advanced prototypes that meet the stated requirements. Reduce size/power requirements for sensor output detection and address manufacturability issues related to full-scale production. Provide prototype system for government testing and initial Warfighter acceptance testing. The prototype fiber and sensor combination should show a good robustness to mechanical stress and abrasion resistance.

PHASE III: Further research and development during Phase III efforts will be directed towards refining a final deployable design, incorporating design modifications based on results from tests conducted during Phase II, and improving engineering/form-factors and manufacturability designs to meet U.S. Army CONOPS and end-user requirements. The initial military application for this technology will be a sensing fiber incorporated into the Warfighter uniform, either as an integral part of the textile or as a patch. The transition from research to operational capability will most likely result from a partnership or licensing agreement with a manufacturer of textile fibers and subsequent incorporation of the sensing fiber into a fabric. The ability to sense dangerous threats to the human body would not only benefit the Warfighter, but also have a significant relevance to first-responder type civilians (police, firefighter, and EMS). Potential for use in civilian markets would depend upon the specific chemical/biological threats the sensor is sensitive to, although it can be envisioned that enclosed-space workers such as underground mining, plant operators and others would likely find use for more portable hazardous gas (hydrogen sulfide, methane, carbon monoxide) sensors.

REFERENCES:
1. The Present State of Amperometric Nanowire Sensors for Chemical and Biological Detection, ARL-TR-3962 Oct. 2006

2. Covington, J.A.; Gardner, J.W.; Bartlett, P.N.; Toh, C-S. Conductive polymer gate FET devices for vapour sensing. IEE Proceeding-Circuits Devices and Systems, 151 (4), 326-334, 2004

3. Crone, B.; Dodabalapur, A.; Gelperin, A.; Torsie, L.; Katz, H.E.; Lovinger, A.J.; Bao, Z. Electronic sensing of vapors with organic transistors. Applied Physics Letters, 78 (15), 2229-2231, 2001

KEYWORDS: textile, chemresistor, chemFET, conductive polymer, sensing fiber, conductive fiber

A10-114 TITLE: Monolithic tunable diode laser absorption spectrometer

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: Develop a monolithic chemical sensor based on laser absorption spectroscopy.

DESCRIPTION: The Chemical and Biological defense community has the need for a miniature, highly sensitive, and specific sensor for detection of chemical agents and toxic industrial chemicals. Infrared absorption spectroscopy has proven to be a very useful tool in the detection and precise identification of airborne chemicals. Pattern recognition is used to compare the infrared spectrum of library molecules against the infrared spectra of airborne contaminants. Infrared spectrometers have rapid response and clear-down times, which provide utility in cloud tracking and dynamic monitoring experiments.
A miniature monolithic spectrometer that is rugged and consumes very little energy would have utility within the chemical/biological defense community. Several military gas-sensing applications require widespread, networked deployment of many individual low-cost rugged sensors. Some envisioned applications involve dispersing sensor networks from aircraft without using parachutes. Thus a sensor that is rugged enough to survive a freefall from altitude and still function effectively would be of great value.

Tunable diode laser absorption spectroscopy (TDLAS) is a configurable optical technology for highly sensitive and specific chemical vapor detection. TDLAS technology leverages a very large effort by the telecommunications industry in the development of very small, rugged, reliable laser sources. Sensors incorporating mature well-packaged wavelength-stabilized near-infrared lasers, developed for the telecommunications industry, have been successfully used to detect toxic gases. Recently developed mid-IR lasers, particularly quantum cascade devices spanning wavelengths of 3-12 µm, have been used to sense sub-ppm concentrations of hydrocarbons in real-time. Compact TDLAS systems can operate continuously at room temperature, without maintenance, cryogenics, or user attendance.

It has recently become possible to construct a complete chemical sensor using monolithic fabrication techniques. Using monolithic fabrication, the chemical sensor, including laser, sampling element, and detector, can be fabricated as a monolithic unit using established production techniques. A monolithic integrated optic TDLAS platform would significantly reduce costs compared to current commercially available systems while providing the sensitivity and selectivity needed for military missions. The integrated optic TDLAS platform would enable inexpensive mass fabrication and miniaturization. The improved ruggedness of the proposed sensor would significantly improve the utility of the system.

PHASE I: Design an integrated optic TDLAS chemical sensor platform concept, combining the laser, sampling element, and detector onto a monolithic platform that can be fabricated or assembled using established production techniques. Identify and design means for minimizing and controlling power consumption while maintaining laser wavelength stability. The design will also include an electronic control and processing module, as well as a power supply and packaging with a goal of a final sensor package that is comparable in size to a rugged cellphone. Demonstrate by calculation the ability to detect chemical warfare agent and simulant vapors at relevant concentrations. For this demonstration, the ability to detect the chemical simulant triethylphosphate at a concentration of less than 1 milligram per cubic meter at ambient temperature and pressure should be demonstrated. Validate experimentally the feasibility of meeting the targeted sensitivity.

PHASE II: Build and test a TDLAS based chemical sensor with an integrated monolithic laser, sampling element and detector. The sensor package should include an electronic control module, power supply, and packaging. The control module should contain all necessary algorithms for detecting chemical agents and simulants. Rigorously test the sensor performance. Use ROC curve analyses to quantify detection sensitivity. Demonstrate sensor ruggedness. Evaluate production costs.

PHASE III: Further research and development during Phase III efforts will be directed towards refining a final deployable design, incorporating design modifications based on results from tests conducted during Phase II, and improving engineering/form-factors, equipment hardening, and manufacturability designs to meet U.S. Army CONOPS and end-user requirements. There are many environmental applications for a small chemical sensor. A rugged, monolithic chemical sensor will benefit the manufacturing community by providing finely tuned monitoring of chemical processes. Also first responders such as Civilian Support Teams and Fire Departments, have a critical need for a rugged, inexpensive, and versatile sensor that can be transported to the field to test for possible contamination by CW agents and other toxic chemicals.

REFERENCES:
1. P. Werle, R. Mücke, and F. Slemr, "The limits of signal averaging in atmospheric trace-gas monitoring by tunable diode-laser absorption spectroscopy (TDLAS)", Applied Physics B: Lasers and Optics, Volume 57, Number 2, Pages 131-139, August, 1993

2. K. Song, H.K. Cha, V.A. Kapitanov, Yu.N. Ponomarev, A.P. Rostov, D. Courtois, B. Parvitte, and V. Zeninari, "Differential Helmholtz resonant photoacoustic cell for spectroscopy and gas analysis with room-temperature diode lasers", Applied Physics B: Lasers and Optics, Volume 75, Numbers 2-3, Pages 215-227, September, 2002

3. R. Kormann, H. Fischer, C. Gurk, F. Helleis, Th. Klüpfel, K. Kowalski, R. Königstedt, U. Parchatka and V. Wagner, "Application of a multi-laser tunable diode laser absorption spectrometer for atmospheric trace gas measurements at sub-ppbv levels", Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, Volume 58, Issue 11, Pages 2489-2498, September 2002.

4. M. Druy, M.B. Frish, and W.J. Kessler, "From laboratory technique to process gas sensor – The maturation of Tunable Diode Laser Spectroscopy", Spectroscopy, Volume 21, number 3, pages 14-18, March 2006.

KEYWORDS: Chemical Detection, TDLAS, Monolithic, diode laser, infrared spectroscopy, integrated optics

A10-115 TITLE: Manufacturing Development of Biomimetic Tissue Engineering Scaffolds

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Design, prototype and demonstrate a cGMP compliant technology for manufacturing a novel biomimetic tissue scaffold for regenerating bone, nerve, vascular, and/or other connective tissue, acceptable for small scale cGMP production of clinical trial materials. A priority of need exists for electrospinning and advanced porogen leaching manufacturing technologies.

DESCRIPTION: The controlled fabrication of scaffold devices for tissue engineering is becoming increasingly promising as a viable technology for regenerative medicine. While few, tissue scaffolds have been developed and marketed to enable tissue engineering-based repair and replacement of lost tissue, including bone scaffolds, none of these marketed scaffolds are suitable for regenerating large tissue losses of the head and extremities commonly observed in casualties returning from Operation Iraqi Freedom and Operation Enduring Freedom. These patients require US Food and Drug Administration (FDA) approved scaffolds effective in the regeneration of large bone, nerve, vascular, and connective tissue defects. They must mimic the natural attributes of extracellular matrix, particularly regarding pore sizes of 1 micrometer, yet sufficiently durable in their manufactured state to withstand surgical manipulation and placement. The manufacturing technology must overcome known barriers related to sterilization, design precision, stability at ambient temperature, and bioburden. The solution provided by this SBIR project will be a demonstration of a novel compliant current Good Manufacturing Practices (cGMP) technology capable of sustaining a supply of a specific tissue scaffold for clinical development studies (i.e, Phase II and III studies). The intent of this project is to accelerate development of manufacturing technology for an innovative scaffold device that translational research has shown to be suitable for the military indication described above, yet due to novel manufacturing innovation required threatens the timely availability of those devices to treat patients. Technology barriers to overcome are significant, and include meeting scaffold design specifications (e.g., but not limited to porosity, degradability, durability, sterility, bioburden free, purity, rigidity, and stability), cost efficiency, and capacity.

PHASE I: Design and prototype the proposed manufacturing technology, and acquire proof of principle data sufficient to warrant proceeding to Phase II. Identify signficant risks in attaining scaffold design specifications and describe how those risks will be mitigated.

PHASE II: Using results from Phase I, demonstrate the capacity, capability, and costs associated with small lot manufacture of the scaffold while meeting critical design specifications. The demonstration must comply with the requirements and format for filing a Device Master File (DMF) or equivalent to the US FDA. Update estimates for equipment (and capital costs), cost of goods sold (COGS), and risks associated with the clinical production of the chosen innovative scaffold device. It is important that the Phase II demonstration provide data needed to support completion of an Engineering Analysis in Phase III.

PHASE III: The end-state of this research is a fully complete manufacturing system sufficient to support Phase III clinical trials of tissue engineering approaches to treat the military patient population. This system will support the mid-term objectives of the Armed Forces Institute of Regenerative Medicine (AFIRM) program. While additional capacity may be required to meet total market needs, the basic manufacturing technology developed under this project should meet initial investigational needs, essentially meet FDA requirements for investigational studies, and be clearly associated with business and medical partnerships that favor successful commercialization long term.

REFERENCES:
1. Zigang Ge1, Zhaoxia Jin and Tong Cao; Manufacture of degradable polymeric scaffolds for bone regeneration; Biomed. Mater. 3 (June 2008)

2. Hollister, Scott J; Scaffold engineering: a bridge to where? A Topical Review; Biofabrication 1:2009, pp 1 - 14 (doi: 10.1088/1758-5082/1/1/012001)

3. Lin CY, Kikuchi N, Hollister SJ. A novel method for biomaterial scaffold internal architecture design to match bone elastic properties with desired porosity. J Biomech. 2004 May;37(5):623-36.

4. Wargo, Sara; Russell, Alan J., and Holcomb, John B.; Military Needs and Solutions in Regenerative Medicine; Prin Regenerative Med, 2008, pp 1322-1332 (doi:10.1016/B978-012369410-2.50079-6)

5. Sangamesh G. Kumbar, S. Nukavarapu, R. James, M. V. Hogan and C. T. Laurencin; Recent Patents on Electrospun Biomedical Nanostructures: An Overview. Recent Patents on Biomedical Engineering 2008, I:68-78.

KEYWORDS: tissue, scaffolds, regenerative medicine, manufacturing systems, manufacturing technology, military, AFIRM, cGMP, bone, cartilage, nerve, polymeric, synthetic, quality systems, fabrication, manufacturing productivity

A10-116 TITLE: <u>Miniaturized Fluidic Chip for Impedance Monitoring of Vertebrate Cells</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Develop a microfluidic chip and integrated support system capable of long-term maintenance and impedance monitoring of vertebrate cells for use in water testing that incorporates multiple label-free cytotoxicity endpoints.

DESCRIPTION: Toxicity sensors provide a tool for rapid monitoring of a wide range of toxic industrial chemicals (TICs) in drinking water. Vertebrate cell monolayers are capable of responding to TICs with rapid changes in electrical impedance (Keese et al. 1998; van der Schalie et al., 2006). A fluidic chip for impedance sensing of vertebrate cells has been developed (Curtis et al. 2009), but it has significant limitations. The size of the chip (9cm x 3.5cm x 1cm) and its media demands (4 mL per chip per day) necessitates support elements with size, weight, and power requirements that greatly limit its application for assessment of field drinking water supplies. Also, it uses only a single sensing endpoint (impedance), and the maintenance of viable cells on the chips for long periods of time prior to testing – necessary for a practical field test system - is problematic. Recent technological advances using multiparameter cellular sensing (e.g., Thedinga et al., 2007) provide promise for improved toxicity detection over using the single parameter of cellular impedance. Furthermore, advances in lab-on-a-chip technologies have demonstrated that cells can be maintained at the micro-scale for several days, but only with large external fluid delivery and maintenance systems (as in Curtis et al. 2009). Cell maintenance systems that are integrated into the chip are plausible (Glawdel et. al. 2009), but to date this technology does not have the capability to provide label-free multiparametric cellular sensing with size, weight, and supporting elements that are compact and robust enough for sustained field portable drinking water applications. The goal of this topic is to merge advances in label-free multiparametric cellular sensing with microfluidic technology to develop a truly field portable fluidic chip with integrated supporting elements that can improve long-term cell maintenance and cytotoxicity sensing capabilities for field use.

PHASE I: Provide a proof of concept demonstration of a microfluidic chip for vertebrate cells with integrated maintenance system. 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. Develop a microfluidic chip with dimensions significantly smaller than the current chip (9cm x 3.5cm x 1cm) and constructed using biocompatible materials that are sufficiently inexpensive for the chip to be disposable. Media sensing, storage, and replacement volumes should be on the order of µL or nL. Sensing electrodes should be present and allow for continuous monitoring of an overlying cell monolayer. The chip design should allow for introduction of distinct test and control water samples. The chip design should allow monitoring of multiple label-free cytotoxicity endpoints including electrical impedance, and provide a connection for data transmission and analysis. To ensure cell viability, the chip must remain sterile until needed for water sample analysis, but sterility need not be maintained during the short time (1-2 hours) required for water testing.
2. Provide for extended viability of a selected vertebrate cell line for at least 45 days on the chip. Demonstrate cell health by showing that impedance values or other measures of cell viability are maintained over time and by successfully completing a cell viability assay at the end of the monitoring period. Data generated from seeded microfluidic chips must show consistent data output at any time from day one to day 45 after storage.
3. Design a microfluidic chip transportation unit to support 10 or more microfluidic chips for at least 45 days and maintain the cells in a ready state for water sample testing. The transportation unit design should maintain cell health by providing fresh media (if necessary) and temperature control. Use carbon dioxide-impervious materials and appropriate culture media so a CO_2 atmosphere is not required. Preference will be given to design concepts that minimize size, weight, and power requirements, that maximize the number of fluidic chips that can be maintained, that eliminate the need for media replenishment, and that provide for ease of use in water sample testing.

PHASE II: Expand upon Phase I proof of concept demonstration to develop a prototype transportation unit and chip analysis system that includes the microfluidic chips. The transportation unit should contain all supporting elements needed to maintain healthy vertebrate cell monolayers on the fluidic chips, and the length of time that cells are usable should be increased to at least 90 days. Demonstrate transportation unit capabilities for cell viability and impedance data acquisition under field-relevant conditions of transportation and use. Develop a chip analysis system for field testing of the microfluidic chips. The chip analysis system may be integrated with the microfluidic chip transportation unit or may be an independent hand-held reader. Design concepts should minimize size, weight, power requirements, and provide for simplified operation with automated analysis of results. Demonstrate using the chip analysis system to inject water samples under field-relevant conditions for testing and show that consistent impedance readings are maintained across multiple chips. Demonstrate sensitivity to toxicants using a range of chemicals (van der Schalie et al., 2006). Provide transportation and chip analysis system with microfluidic chips for independent evaluation and testing.

PHASE III: Integrate the transportation and chip analysis system with the Environmental Sentinel Biomonitor (ESB) system under development at the U.S. Army Center for Environmental Health Research (USACEHR). The improved transportation and chip analysis system will increase the ability of the ESB system to be used for evaluating the suitability of drinking water for deployed troops under field conditions. Field tests will involve shipping the transportation and analysis system to Army field sites and testing toxicity sensing capabilities. 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. In addition, modular systems for maintaining vertebrate cell systems should be broadly usable for high-throughput screening of pharmaceutical products for efficacy and toxicity.

REFERENCES:
1. Curtis, T.M., Widder, M., Brennan, L., Salazar, N., van der Schalie, W., 2009. A Portable Cell-based Impedance Sensor for Toxicity Testing of Drinking Water, Lab on a Chip, 9:15, 2176 – 2183.

2. Glawdel, T., Elbuken, C., Lee, L., Ren, C., 2009. Microfluidic System with Integrated Electroosmotic Pumps, Concentration Gradient Generator and Fish Cell Line (RTgill-W1)-Towards Water Toxicity Testing, Lab on a Chip, 9,3243-3250.

3. Keese, C.R., Karra, N., Dillon, B., Goldberg, A.M., Giaever, I., 1998. Cell substratum interactions as a predictor of cytotoxicity. In Vitro Molec. Toxicol. 11, 182–193.

4. Thedinga E, Kob A, Holst H, Keuer A, Dreschsler S, Niendorf R, Baumann W, Freund I, Lehmann M, Ehret R. 2007. Online monitoring of cell metabolism for studying pharmacodynamic effects. Toxicology and Applied Pharmacology 220:33-44.

5. van der Schalie WH, James RR, Gargan TP, II. 2006. Selection of a battery of rapid toxicity sensors for drinking water evaluation. Biosensors and Bioelectronics 22:18-27.

KEYWORDS: microfluidic chip, toxicity sensor, impedance sensing, vertebrate cells, drinking water, multiparmetric sensing

A10-117 TITLE: Manufacturing Development of Allogeneic Stem Cells in Clinical Settings

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Design, prototype, and demonstrate a cost-effective technology to process and deliver allogeneic stem cells to medical care providers needing such cells for advanced clinical trials in regenerative medicine and cellular therapy. Manufacturing processes must comply with current Good Manufacturing Practices (cGMP), 21 CFR 1271, and good tissue practices, and advance future commercialization of a stem cell processing technology as described below.

DESCRIPTION: Stem cells have the potential to have a dramatic impact in treating many diseases and injuries, including those for which regenerative medicine holds promise, such as massive tissue loss due to combat-related injury. According to U.S. regulations, “manufacturer” means, but is not limited to, “any or all steps in the recovery, processing, storage, labeling, packaging, or distribution of any human cell or tissue, and the screening or testing of the cell or tissue donor" (21 C.F.R. § 1271.10(e)). This project focusses on technology innovation to improve recovery and processing of adult stem cells from donor tissue intended for transplantation into a recipient patient.

Translating the promise of stem cell therapy into clinical application is limited by current cell manufacturing technology, regulatory, and logistics hurdles. The intent of this work is to accelerate the innovation required to overcome these barriers. This technology should ultimately provide high-capacity enrichment of stem cells from donor tissue, a cost effective and leap-ahead cell isolation process for stem cells having relevance to regenerative medicine (i.e., bone, cartilage, nerve, muscle, blood vessels, and fat), and offer a distributed capability for point-of-care isolation and enrichment, if indicated.

PHASE I: Design and prototype a closed system to isolate and enrich with high specificity donor stem cells from unspecified tissue. This technology may use existing immunological based approaches or may use novel approaches for isolating cells, but must result in leap-ahead improvements in the efficiency of enrichment (i.e., % yield / unit of donor tissue) and specificity (i.e., purity) indicated for allogeneic cell therapies. Processing capabilities must satisfy requirements for at least one donor tissue type/stem cell type but evidence should indicate the flexibility to employ multiple tissue and stem cell types. Provide evaluative data indicating the limits of capability of the technology.

PHASE II: Using the results of Phase I, fabricate and demonstrate the capability of the technology under a cGMP environment with sufficient data and design specifications to file a Device Master File with the US FDA or into an Investigational Device Exemption (IDE) filing with the FDA. Filing of the DMF is not a requirement.

PHASE III: The end-state of this research effort will be an "off-the-shelf", cost effective and FDA-approved manufacturing solution for delivering critical allogeneic stem cells to patients, particularly for use in regenerative medicine applications. This outcome will support the US Army's Armed Forces Institute of Regenerative Medicine (AFIRM) objectives to clinically evaluate and translate into medicine innovative regenerative medicine technologies.

REFERENCES:

1. Kirouac, Daniel C. and Zandstra, Peter W.; The Systematic Production of Cells for Cell Therapies; Cell Stem Cell 3: October 2008, pp 369 - 381.

2. Wargo, Sara; Russell, Alan J., and Holcomb, John B.; Military Needs and Solutions in Regenerative Medicine; Prin Regenerative Med, 2008, pp 1322-1332 (doi:10.1016/B978-012369410-2.50079-6)

3. 21 C.F.R. § 1271: HUMAN CELLS, TISSUES, AND CELLULAR AND TISSUE-BASED PRODUCTS

KEYWORDS: regenerative, medicine, stem,cell, allogeneic, cGMP, good tissue practices, bioprocessing, cellular, therapy, military, AFIRM, manufacturing technology, manufacturing productivity quality systems,

A10-118 TITLE: <u>Differentiation of Leishmania in the Sand fly Vector</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: To develop, evaluate and commercialize a multiplexed field deployable assay capable of identifying Leishmania and differentiating between human vs. non-human infecting species from sand flies collected from deployed military service areas. The assay should be able to further differentiate the human infecting Leishmania species.

DESCRIPTION: Effective surveillance relies on quick and accurate detection of a pathogen in its corresponding vector. Effective surveillance provides the ability to assess the true risk of infections as well as help to determine where to focus prevention and treatment programs. To accomplish this surveillance areas are monitored by catching large numbers of the vector from a variety of locations using a variety of traps. The insects then need to be tested for the disease of interest, in this case, Leishmania species. Complicating matters in the surveillance of Leishmania is the fact that human and non human infecting species exist. Not being able to differentiate human infecting species inflates the infection rate of the sand flies possibly causing the improper implementation of prevention and treatment programs. In addition, knowing which human infecting species is currently circulating in an area is extremely important since some species of Leishmania are more virulent and would require more aggressive surveillance and treatment programs. Because this work often takes place in a field setting, a test that is quick, field deployable and accurate for the species determination of Leishmania is needed.

Desired Capability: The goal of this SBIR is to successfully develop and commercialize a multiplexed, field deployable assay to detect and differentiate human vs. non-human infecting species in the sand fly vector. Additionally the assay should be able to determine the species of human infecting Leishmania. The assay should be rapid (less than 4 hours), heat stable (no cold chain required) and have a small logistical footprint. If nucleic acid aid amplification is used, sample preparation should be included in the assay. The assay should be at least as specific as the gold standard assays (culture and iso-enzyme analysis).

Access to govt. facilities and supplies: Reagents, controls, infected sand flies etc, to support this project may be available from the Walter Reed Army Institute of Research (WRAIR). The candidate contractor should coordinate with the Contracting Officer Representative (COR) for any support needed from WRAIR.

PHASE I: The selected contractor will determine the feasibility of the concept by a developing prototype assays (to include any nucleic acid purification and amplification equipment required) that will detect and differentiate human vs. non-human infecting species in the sand fly vector. Additionally the assay should be able to determine the species of human infecting Leishmania. This development will be accomplished using cultured material. Proof of concept will be shown by the contractor by conducting an initial laboratory evaluation of the prototype assay with cultured Leishmania parasites and providing a written report to the COR. By the conclusion of Phase I, the selected contractor must provide the Contracting Officer Representative (COR) with sufficient prototype assays to establish the assay in a government laboratory. This will include any associated instruments and enough assays to carry out 100 tests. The selected contractor must coordinate with the COR to access any required reagents from the WRAIR. The degree to which the prototype assay meets the desired capability outlined above will be evaluated at the government laboratory. Data from this independent evaluation will be used in the determination of the Phase II awardee.

PHASE II: The goal in Phase II is the development of a prototype assay that is a least as sensitive and specific as the current gold standard assays for Leishmania detection and species identification. (culture and iso-enzyme analysis). Once sensitivity and specificity requirements have been met, the selected contractor shall conduct comprehensive laboratory evaluations of the assay performance characteristics (Limit of detection (LOD) sensitivity, specificity, positive / negative predictive value, accuracy and reliability) and initial field testing.
The selected contractor will also conduct stability testing of the device in Phase II. Stability testing should be conducted under both real-time and accelerated conditions. This will be done to attempt to force the product to fail under a broad range of temperature and humidity conditions and extremes.
The Walter Reed Army Institute of Research (WRAIR) may provide additional support in testing and evaluation of the developed device to include field trials. The selected contractor will coordinate well in advance with the COR to any support required by the WRAIR.

PHASE III: During this phase the performance of the assay should be evaluated in a variety of field studies that will conclusively demonstrate that the assay meets the requirements of this topic. By the conclusion of this phase the selected contractor will have completed the development of the assay and successfully commercialized the product. The contractor shall provide a report that summarizes the performance of the assay to the Armed Forces Pest Management Board and will request that a national stock number (NSN) be assigned. Contractor shall coordinate in advance with the COR for any support required from the WRAIR.

Military Application: Once an NSN has been assigned to the assay, the Armed Forces Pest Management Board will work with appropriate organizations to have the assay incorporated into appropriated “sets, kits, and outfits” that are used by deployed Preventive Medicine Units.

Commercial Application: This assay will also be available for non-military purposes, such as use by commercial pest controllers or non-governmental organizations (NGOs) in areas of the world where Leishmania is endemic. We envision that the contractor that develops the Leishmania assay will be able to market this assay to a variety of commercial, governmental and non-governmental vector control organizations, and that this market will be adequate to sustain the continued production of this device. By the end of this phase, the selected contractor shall make this product available to potential users throughout the world.

REFERENCES:
1. Claborn, D., P. Masuoka, et al. (2008). "Habitat analysis of North American sand flies near veterans returning from leishmania-endemic war zones." Int J Health Geogr 7: 65.

2. Coleman, R. E., D. A. Burkett, et al. (2006). "Impact of phlebotomine sand flies on U.S. Military operations at Tallil Air Base, Iraq: 1. background, military situation, and development of a "Leishmaniasis Control Program"." J Med Entomol 43(4): 647-662.

3. Dujardin, J. C., L. Campino, et al. (2008). "Spread of vector-borne diseases and neglect of Leishmaniasis, Europe." Emerg Infect Dis 14(7): 1013-1018.

4. Sharma, N. L., V. K. Mahajan, et al. (2009). "The sandflies of the Satluj river valley, Himachal Pradesh (India): some possible vectors of the parasite causing human cutaneous and visceral leishmaniases in this endemic focus." J Vector Borne Dis 46(2): 136-140.

5. Shehata, M. G., A. M. Samy, et al. (2009). "First report of Leishmania tropica from a classical focus of L. major in North-Sinai, Egypt." Am J Trop Med Hyg 81(2): 213-218.

6. Silveira, F. T., E. A. Ishikawa, et al. (2002). "An outbreak of cutaneous leishmaniasis among soldiers in Belem, Para State, Brazil, caused by Leishmania (Viannia) lindenbergi n. sp. A new leishmanial parasite of man in the Amazon region." Parasite 9(1): 43-50.

7. Simon, S., V. Veron, et al. (2009). "Leishmania spp. identification by polymerase chain reaction-restriction fragment length polymorphism analysis and its applications in French Guiana." Diagn Microbiol Infect Dis.

8. Wasserberg, G., Z. Abramsky, et al. (2002). "The ecology of cutaneous leishmaniasis in Nizzana, Israel: infection patterns in the reservoir host, and epidemiological implications." Int J Parasitol 32(2): 133-143.

KEYWORDS: leishmania, species, differentiation, field-deployable

A10-119 TITLE: Ultrafast Fiber Lasers Smart Surgical Tool Development

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: To develop a fiber based ultrafast laser surgical tool for novel combat casualty care surgical applications, including wound debridement, burn debridement, and selective shrapnel removal.

DESCRIPTION: Ultrafast, or femtosecond, lasers produce a variety of phenomena that are of interest to the Army. Specifically, ultrafast lasers have the capability to cut with a minimal heat affected zone, reducing collateral tissue damage and enabling extreme precision [1]. This phenomenon has been shown to extend to a variety of materials, including soft and hard tissues [2] as well as metals [3], confirming that ultrafast light offers unique characteristics for treatment of trauma and general surgical applications. Ultrafast lasers can also be paired with various spectroscopic techniques, such as Laser Induced Breakdown Spectroscopy (LIBS) to create a feedback loop to assist a surgeon or field technician in surgery [4,5].

Recent advances in fiber ultrafast lasers technology have demonstrated that ultrafast lasers can meet the deployment and cost needs of the Army [6]. This topic seeks to develop a prototype fiber-based ultrafast laser “smart scalpel” capable of being used as a platform for multiple surgical procedures. The Army is particularly interested in technologies and approaches which have size, weight and power advantages, eye-safer wavelengths, and delivery technologies such as optical fiber.

PHASE I: Develop ablation protocols and spectroscopic algorithms as a basis for an ultrafast laser surgical tool and use experimental data to support a proof of concept demonstration of the “smart scalpel” concept. Phase I will focus on critical benchtop research to develop datasets and algorithms for a successful “smart scalpel” developed under Phase II. Specifically, Phase I seeks to achieve:

1) The development of ultrafast laser ablation protocols for a variety of materials of interest for the Army. These include soft tissues (such as dermis, fat celled tissues, e.g. liver), hard tissues (bone, teeth), and metals (heavy metals and other examples of foreign non biologic materials). Data of interest includes laser settings of optimal pulse energy, ablation fluence and pulse repetition rates for maximum material removal, along with accompanying spectroscopic data (e.g. LIBS or other technique capable of material differentiation at a high level of accuracy) and histologic or SEM analysis of ablated samples to demonstrate quality of athermal ablation. Ablation demonstrations are to be in an in vitro environment.

2) Demonstrate a software algorithm capable of differentiating between ablated materials utilizing data collected from a spectroscopic detection system, such as LIBS. The system should show the capability to discriminate tissue types (i.e. hard tissue and soft tissue) or tissue vs. metals (i.e. soft tissue and heavy metals) at 90% accuracy or greater, with a described path for 99% accuracy in future development. The data used in the algorithms may be from experiments derived under the Phase I or drawn from an existing library of spectroscopic data sets.

PHASE II: Develop a prototype integrated ultrafast laser surgical tool based on the benchtop version and system specifications developed during Phase I. The system should include integrated software controls that enable a user to rapidly alternate between optimal ablation settings for multiple tissue types or other materials, as determined by the protocols established in Phase I, and feature real-time spectroscopic feedback leveraging the software algorithms developed in Phase I. Phase II should demonstrate significant advances in packaging and weight considerations, targeting less than 75 pounds total system weight, and include a beam delivery mechanism and a capability for practical material removal. The packaged surgical tool will be delivered, tested and qualified at a site of the Army’s choosing.

PHASE III: Final system specifications will be designed and implemented based on the deployment theater (i.e. field vs. hospital deployment). Specific surgical applications will be selected by the Army for study. Testing will occur in preclinical and clinical studies, culminating in FDA approval in surgical procedures and theater deployment.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Ultrafast laser technology has significant benefits in a variety of surgical applications which apply to both the warfighter and civilians. For example, burn debridement applications will have significant use for civilian burn management. There is also expectation for significant opportunity in orthopedic and traumatic surgical applications.

REFERENCES:
1. B-M. Kim, M.D. Feit, A.M. Rubenchik, E.J. Joslin, P.M. Celliers, J. Eichler, and L.B. Da Silva, “Influence of pulse duration on ultrashort laser pulse ablation of biological tissues,” J. Biomed. Opt. 6, p332 (2001).

2. L.B. Da Silva, B.C. Stuart, P.M. Celliers, T.D. Chang, M.D. Feit, M.E. Glinsky, N.J. Heredia, S. Herman, S.M. Lane, R.A. London, D.L. Matthews, J. Neev, M.D. Perry, and A.M. Rubenchik, “Comparison of soft and hard tissue ablation with sub-ps and ns pulse lasers,” Proc. SPIE 2681, p196 (1996).

3. A. Ancona, C. Jauregui, S. Doring, F. Roser, J. Limpert, S. Nolte, A. Tunnermann, “Ultrashort pulse laser drilling of metals using a high repetition rate, high average power fiber CPA system,” Proc. SPIE 7203 (2009).

4. T. Tong, J. Li, and J.P. Longtin, “Real-time control of ultrafast laser micromachining by laser-induced breakdown spectroscopy,” Applied Opt. 43, p1971 (2004).

5. H. Zheng, F.Y. Yueh, S. Burgess, and J.P. Singh, “Laser induced breakdown spectroscopy: application to tissue analysis,” in Laser Applications to Chemical, Security and Environmental Analysis, Technical Digest (Optical Society of America, 2006), paper TuE7.

6. M. Mielke, D. Gaudiosi, K. Kim, M. Greenberg, X. Gu, R. Cline, X. Peng, M. Slovick, N. Allen, M. Manning, M. Ferrel, N. Prachayaamorn, and S. Sapers, “Ultrafast Fiber Laser Platform for Advanced Materials Processing,” Proceedings of LAMP2009 - the 5th International Congress on Laser Advanced Materials Processing.

KEYWORDS: ultrafast laser, surgical tool, wound debridement, burn debridement, spectroscopy

A10-120 TITLE: Laser Vibrometry Detection of SBIEDs

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a quick and reliable system to identify Suicide Bomber IEDs (SBIEDSs) at extended ranges of 100 meters or more employing the most recent advances in scanning laser vibrometry analysis (SLV).

DESCRIPTION: The potential to identify explosives on suicide bombers at extended ranges of 100 meters or more is a critical need. A number of possible standoff sensor technologies have been explored which include the use of laser explosive detection systems, high frequency radar systems, Terahertz sensor systems, and near IR or IR camera systems. Reliable and quick explosive detection is difficult when layers of clothing, shielding or other methods are employed to conceal or contain the explosive materials. Sufficient target resolution, detection, and classification performance at ranges of 100 meters or more has been a formidable challenge.

The potential exists to explore the latest advances in scanning laser vibrometry analysis (SLV) to make SBIED detection fast and reliable. Laser standoff vibrometry analysis has been successfully employed for structural analysis of buildings and structures at extended ranges. Most recently SLV has been utilized for extremely fine detail analysis of structural defects in microstructures or microcircuits. The basic idea behind the employment of SLV is to measure and analyze the delicate structural velocity changes of a medium as it is excited within the environment or through purposeful excitation. Area 2-D and 3-D velocity maps created through SLV scans of a structure reveal imperfections of a structure and also identify structural resonance frequencies which provide potential insight into the underlying structural makeup. SLV analysis is extremely sensitive and can operate at large standoff distances, e.g. SLDV analysis of sensitive artwork can reveal what areas need reconditioning; SLV body scan analysis is capable of detecting a person's heartbeat over various parts of a person's body, at extended distances and even through clothing. SLV has the advantage of allowing flexible PC control and quick digital data analysis within existing applications such as MATLAB.

The technical challenges can be summarized as 1) In accordance with the Explosive Ordinance Disposal plan, the distance to which it is necessary to evacuate in the presence of explosives is dependent upon the weight and type of the explosives being used. On average, the distance required for safe evacuation is approximately 100 meters. 2) In addition to sufficient stand-off distance it is also necessary for the imaging system to have a pinpoint accuracy of scans across critical body target areas to improve target detection reliability while maintaining eye safe operation 3) the system should be ultimately capable of scanning personnel while they are on the move 4) the system should ultimately be capable of automatic identification of critical target scan areas which exist within a crowd of personnel with Line of Sight aspect to the system. 5) In order to enhance system effectiveness and allow realistic operation within more complex multiple personnel environments, the use of multiple sensor systems operating at different vantage points may be required.

PHASE I: Preliminary design, concepts and algorithms to implement a stand-off system to identify explosives concealed under clothing by segregating human generated vibrational signatures from those produced by the explosives and their associated components. The system should have the ability to detect explosives from a stand-off distance of 100+ meters with the ability to isolate individuals of interest with a narrow and adjustable field-of-view.

Success at PHASE I should demonstrate the ability to identify explosives beneath clothing on a person. A detailed design of hardware components and software platform should be provided.

PHASE II: The Phase II effort will involve the production of a prototype to demonstrate functionality. A deliverable prototype of the system should comprise usable hardware and software. The system should function without compromising system accuracy, efficiency and field of view. Software will consist of algorithms that provide real-time interactive recognition for all target individuals including those who are uncooperative in unconstrained indoor and outdoor situations at a distance of at least 125 meters from the target. Real-time testing and evaluation of performance of the integrated hardware and software system should verify functionality.

PHASE III: PHASE III: The ability to identify concealed explosives on suicide bombers at safe evacuation distances provides the potential to save countless lives. Determining a person of interest prior to them committing a catastrophic act will allow for sufficient time to implement an appropriate response. Phase III effort involves integrating the results into existing military and commercial applications as well as exploring additional applications. Military applications include protection at critical entry control points, border patrol, stand-off interrogation, wide area situational awareness, surveillance, crowd monitoring and airport security.

REFERENCES:

1. DTIC references AD number ADA429041 and ADD342826.

2. Targeting the Limits of Laser Doppler Vibrometry - http://www.polytecllc.net/v2009/pdf_documents/technical_papers/TargetingtheLimitsofLaserDopplerVibrometry.pdf

3. Drain, L.E., 1980, The Laser Doppler Technique, New York: John Wiley & Sons Ltd.

4. P.Castellini, G.M.Revel, E.P.Tomasini, "Laser Doppler Vibrometry: a Review of Advances and Applications", The Shock and Vibration Digest, vol.30, No.6, pp.443-456, November 1998, Sage Science Press, Thousand Oaks, CA.

KEYWORDS: laser vibrometry, scanning, IED, suicide bomber detection, target classification

A10-121 TITLE: <u>DIm and Imperceptible Tracer Ammunition Product Development</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Design, develop and demonstrate components, technologies and products required for small caliber tracer ammunition that can only be visible by the shooter, given appropriate operator approval of target engagement. Tracer ammunition that is imperceptible to the enemy, and perceptible to friendly forces is also desired

DESCRIPTION: Tracer ammunition in the 5.56, 7.62 and .50 caliber families of ammunition continue to be a reliable and valuable means of target engagement for the mounted and dismounted warfighters throughout conventional joint and coalition warfare. The asymmetric threat and the evolution of tactics and techniques have revealed emerging requirements to develop the means to allow friendly forces to shoot dim or imperceptible tracer ammunition that cannot be perceived by enemy forces. The current configuration of conventional tracer ammunition does not currently satisfy this. Technologies, components and complementary devices that can be demonstrated, tested and produced are to be sought and developed. The main users of this ammunition include the dismounted rifleman, machine gunner, sniper, as well as gun crews onboard ground vehivles and army aviation aircraft. It is envisioned that near and far term solutions would include the collaboration of target engagement to take place. A combined use of preexisting, in-the-field vision products that include but is not limited to: close combat optics, night vision, and eye safe laser eyewear, can augment or enhance the capability sought for dim and imperceptible ammunition. This combined engagement capability should be developed in a manner that maintains current tracer performance in lethality, range, and reliability. User validation, producibility, reliability and manufacturing maturity will be key criteria for the success of technology and/or products proposed

PHASE I: Investigate innovative designs, concepts and techniques. Develop and validate a key performance scenario with the user for demonstration. Demonstrate a proof of principle of the design by showing a mission thread which demonstrates concept or capability. Conduct a producibility analysis of the concept compared with like tracer products. Focus on one proposed product concept from the family of tracer ammunition from 5.56, 7.62 and .50 caliber with one weapon system

PHASE II: Develop and demonstrate a prototype capability (i.e., produce ammunition) for insertion into a realistic, ARDEC-supplied fires and effects scenario. The ammunition must be capable of integration and operation within the Army operational architecture. Conduct a controlled field test to demonstrate feasibility of the component for operation within a simulation environment, and with actual conventional ammunition and and weapons systems currently in use by the Army. Evaluate technology and product maturity

PHASE III: The capability will be studied for transition into a pilot production program to reliably produce, test and validate the performance, reliability and acceptance of the product by the user. Data collection will be conducted to determine the criteria for product acceptance, reliability and test and evaluation of performance in the field. If feasible, additional weapons systems applications will be evaluated. Dual use applications in all other family of ammunition tracer products will be investigated and a feasibility study will be conducted. This capability will also be leveraged for use by Joint and special operations applications, from which a user evaluation will be conducted. Product maturity will assessed to determine the final transition into further development, maturity and feasibility of use

REFERENCES:
1. http://www.army-technology.com/contractors/ammunition/ruag/press5.html, Snipers' Ammunition SWISS P .50 (12.7mm x 99mm)

2. www.Nationaldefensemagazine.org/archive/2002/August/, U.S. Commandos Test New 5.56 mm Dim Tracer Ammo August 2002

3. http://www.nammo.com/templates/technologies.aspx?id=130, IR- / Dim Tracer: Dim Tracer is totally invisible to the naked eye

4. http://www.atk.com/customer_solutions_armamentsystems/cs_as_ma_sc_7.62mm.asp

5. http://www.c4isrjournal.com/story.php?F=3015687, Owning the night: Infrared and thermal sensors are fused on the battlefield

6. http://www.rense.com/general26/isratw.htm

7. http://www.fas.org/man/dod-101/sys/land/gdt.htm, Generic Dim Trace, 5.56mm, XM996, Dim Tracer Cartridge 7.62mm, M276, Dim Tracer Cartridge, Caliber .50, Dim Tracer Cartridge

8. http://www.globalsecurity.org/military/systems/munitions/gdt.htm

9. http://www.biggerhammer.net/barrett/fas/

KEYWORDS: Design, develop, demonstrate, components, technologies, products, small caliber, ammunition, visible by shooter, tracer ammunition, dim, imperceptible, perceptible to friendly forces

A10-122 TITLE: Lightweight EMI Resistant Wiring Solutions

TECHNOLOGY AREAS: Air Platform, 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 topic is to demonstrate and develop technologies to reduce the EMI susceptibility and impact of both existing and future power wiring harnesses on Army aviation platforms.

DESCRIPTION: Network centric operations are a major driver for future Army Aviation requirements. As additional technology and advanced systems are integrated onto aviation platforms, there are more and more sources for potential EMI/EMC issues. The requirements (both system and subsystem) for conducting electromagnetic/electronic environmental effects (E3) testing are both costly and time consuming. Two major areas of electromagnetic vulnerability are wiring and connectors. Many issues arise from the increased need for power wiring and mixed (both power and various signal types) harnesses. Having power wiring in such close proximity to signal wiring and connectors can cause problems with inducing electromagnetic interference. This also causes increased cost due to the amount of testing needed to support airworthiness qualification of the aircraft after new technology insertion.

This topic will look at new technologies that can help reduce the potential for EMI/EMC susceptibility and emissions of wiring harnesses and connectors, particularly the power wiring and power connectors. This will help to reduce the impact of new technology insertions on aircraft as well as help reduce the costs of qualification of new systems. These issues are not unique to aviation platforms. Ground based platforms face of many of the same barriers that aviation platforms encounter when it comes to EMI/EMC with respect to new technology insertions.

Offerors may consider (but are not limited to) material solutions like new connector enclosures, new packaging techniques, coatings, blankets, shielding, derived neutrals or local grounding, or other exotic techniques (e.g., active cancellation) for suppressing EMI emissions. Offerors should investigate EMI/EMC impacts on these types of harnesses as well. Approaches may also include metallic materials, non-metallic wires, and other non-traditional technologies. Methodology may involve implementation of new types of wiring or transmission medium and connectors or just novel approaches to the shielding of traditional signal carriers and interconnects. Due to weight and size constraints, many harnesses contain both power and signal wires in the same bundle. The material solution must be optimized for both weight and cost. It should not add any significant weight to the aircraft and should maintain the same basic form factor as current aircraft wiring harnesses. Both active and passive solutions will be considered. Solutions should be flight worthy and be able to operate in a rotorcraft environment. Potential solutions should be optimized for durability and maintainability in an Army rotorcraft environment.

PHASE I: The contractor will conduct a study of Army combat helicopter wiring harnesses (to include wires, cables, connectors) to establish an E3 baseline condition for power wiring. The contractor will also look at future technology insertions. The contractor will use this information to verify his proposed EMI suppression solution and compare and contrast it to other candidate solutions. The contractor will conduct detailed design, define associated test and implementation processes, and analyze effectiveness versus baseline and modified E3 conditions. The contractor will optimize the design for overall EMI suppression effectiveness and durability as well as maintainability, cost effectiveness, minimization of logistical and maintenance impacts, and mitigation of weight added to the platform. The top factors for this will be for EMI suppression, weight, and cost in that order. The contractor will conduct a proof of concept technology demonstration of key technologies to validate the proposed approach.

PHASE II: The contractor will finalize system design, define associated processes, develop and document the system, draft test plans and procedures, fabricate a prototype, and test the prototype system and procedures in a relevant operating environment. The contractor will define necessary test equipment and instrumentation, and conduct required testing (or be present to monitor compliance with test plans). The contractor will prepare test reports and present results to the Government and other interested, relevant parties. Testing will include at a minimum all relevant sections of MIL-STD-461E as well as MIL-STD-810F.

PHASE III: The contractor will research and market potential applications to other DoD aviation weapon systems and to commercial aviation. The contractor should also focus on potential applications to ground based platforms. PEO Aviation has a need across all platforms to reduce the electromagnetic impact of new equipment and existing systems. Other potential applications will be across commercial aviation assets and other government agencies.

REFERENCES:

1. MIL-STD-461E, MIL-STD-810F, DO-160B, MIL-STD 2

KEYWORDS: Aviation, Light-weight material, EMI resistent, wiring, power wiring, connectors

A10-123 TITLE: Ultrastrong Dual Use Nanocomposite Materials for Blast and Transparent Armor

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop ultra strong composite materials, to be manufactured into lightweight transparent armor to balance the "iron triangle" of payload, protection and performance for both new platforms (like JLTV) and current platforms like MRAP and HMMWV military vehicles. The goal of ultra strong composite material is the need beyond the existing material technologies for lighter weight, low cost materials with higher toughness and hardness, for application in ballistic and blast mitigation requirements. The baseline for ultra strong composite materials performance is RHA material.

DESCRIPTION: Current transparent armor formulations are the Achilles heel in tactical vehicles due to their high weight and thickness, which pose integration challenges and performance and payload penalties. These burdens often result in the minimization of windows, which decreases situational awareness and increases the platform's vulnerability. This solicitation focus and objectives are to address those challenges by creating a lighter, and thinner transparent armor compare to the current technology used on vehicles. These technologies are needed to withstand the lethal effects of roadside explosions to a minimum injury levels. This solicitations focus is in the design and development of next-generation light weight blast resistance and transparent armor materials. Recently, high strength nano-to-micro-scale composite materials have been developed by a new layer-by-layer (LBL) assembly approach [4]. The LBL composites from nano particles have demonstrated substantially better mechanical properties than the traditional composite or polymers. [1] Significant progress has been made in demonstrating the high tensile strength, stiffness, and electrical conductivity of LBL composites reinforced with clay nano sheets and carbon nano tubes [5, 6]. This solicitation seeks to develop novel advanced materials that are based on hierarchical assembly of composite structures to be used to manufacture lightweight blast mitigating shields for military purposes. Current transparent armors have generated major set-backs. They are generally heavy and thick, thereby, exerting additional burden on the vehicle structure, increase in fuel consumption and decreased maneuverability [1]. The high performance Aluminum oxynitride (AlON) and sapphire (Al_2O_3 single crystal) have demonstrated improved ballistic performance in comparison to other known transparent armor materials [2, 3]. However, laminated transparent sapphire and AlON armors are quite expensive to manufacture. They also have difficulties producing curved parts. Ultra strong nanocomposite structure materials have been developed by the layer-by-layer (LBL) assembly [4]. This involves sequential dipping of a substrate in solution of positively and negatively charged polyelectrolyte's or nanocolloids, depositing nanometer scale layers of the different components, one at a time [5]. The LBL composites, which are based on hierarchical organization of clay-polymer nanoplatelets, have demonstrated high stiffness, tensile strength, and optical transparency compared with existing technology. Based on the high level of ordering of the nanoscale building blocks and sufficient chemical bonding, it is now possible to realize effective stress transfer from a matrix to the individual high-strength components. LBL and similar composite materials can potentially be used in the design and development of next-generation lightweight blast resistance and transparent armor materials. However, due to the step-by-step fabrication approach, the LBL process is slow, hence, difficult to apply for large scale production of transparent armor shields. Innovative high-risk, high-gain approaches to manufacturing of ultra strong transparent composites and acceleration of LBL manufacturing and without significant weight add-on are needed. The ability to manufacture curved shapes is highly desirable.

PHASE I:
1) Demonstrate feasibility of manufacturing LBL-assembled materials with an approach to accelerate manufacture of ultra strong LBL nanocomposite materials that incorporate high amounts of nanoscale building blocks. Investigate processes.
2) Perform feasibility studies and develop an analytical methodology for the design and development and manufacturing of Ballistic and Blast Mitigation armor panels dimensions based on a given material properties, threat levels and the occupants protection levels.
3) Demonstrate manufacturing of two prototypes, transparent armor of lightweight LBL nanocomposites measuring 60cm x 60cm x4 mm to be tested for ballistic and mine blast mitigation per light weight tactical vehicle requirements.
4) The Transparent Ballistic panel hardness and toughness shall defeat 30 caliber 7.62 mm bullet threat at 2800 feet per second.

Transparency requirements are: with 80% transmission of the maximum solar emission of 550 nm.
Refraction coefficient should be that similar to glass, that is 1.45.Dispersion characteristics in the Wavelength range 400-800 nm. Stability of the Index of Refraction should be in the range of -20 C to +40 C.

The Blast mitigation panels shall be designed with toughness and hardness to meet the STANAG 4569 specifications for occupant protections.
1) Perform proof of concept tests one each for armor and mine blast using two 60cm x 600cm panels with thicknesses calculated based on the developed analytical methodology. The ballistic and mine blast tests shall be based on the threat levels for light and medium weight tactical vehicles per NATO Ballistic STANAG 4569 specifications for occupant protections.
2) Develop detailed technical cost and cost savings analyzes for large scale manufacturing of ultra strong LBL nanocomposite materials.

PHASE II: Pending the positive outcome in Phase I.
1) Develop and demonstrate capabilities for large-scale manufacturing of both large area pieces and large 1000 quantities per hour for ballistic and blast panels of ultra strong transparent LBL nano composites materials.
2) Demonstrate six (6) coupons 122cmx122cm, two for mine blast and two for ballistic tests conducted by the contractor. The remaining two panels to be Ballistic tested at TARDEC to verify contractor test performance. The Coupons thicknesses shall be calculated using the developed methodology meeting NATO Army STANEG 4569 requirements for occupant protection in light and medium weight tactical vehicles. The Ballistic panel hardness and toughness shall defeat 50 caliber 15 mm bullet threats at 3000 feet per second.
3) Develop and validate the computational algorithm per analytical methodologies developed in phase one for manufacturing of ballistics and Blast mitigation panels.
4) Validate the developed computational algorithm based on the four coupons tests
5) The additional Two (2) coupons shall be tested at TARDEC ballistic facilities confirming the contractor results.

PHASE III: Provide cost analysis and affordability for fabrication of lightweight transparent armor, and blast deflector for military vehicles. Other areas of applications include military aircrafts, transparent shields for soldiers and law enforcement vehicles, Armor, windshields & Blast deflector, Protection Shields for fire fighter & Force protection applications GDLS, BAE Systems, Lockheed Martin, Boeing Armor and Blast Mitigating Deflectors.

COMMERCIAL APPLICATION: LBL-based ultra strong materials will have tremendous use for the airline industry and in civilian settings. The creation of this alternative technology will have a broad range of commercial applications. Not only will it directly impact military vehicle ballistic and structural blast resistance capabilities, it will also be applicable to civilian defense issues and automotive safety issues. Commercial applications can range from the aircraft industry to the auto and shipping industry. Military applications will benefit light weight Tactical vehicles enhancing the agility, survivability and mobility of the vehicles. It will also reduce fuel consumptions and to increase the mobility and speed of deployment of our armed forces.

REFERENCES:
1. http://www.military armor protection.com/

2. Klement, R.; Rolc, S.; Mikulikova, J. K., Transparent Armor Materials, J. Eur. Chem. Soc. 2008, 28, 1091-1095.

3. McCauley, J, W.; Patel, P.; Chen, M.; Glide, G.; Strassburger, E.; Paliwal, B.; Ramesh, K. T.; Dandekar, D. P., Alon: A Brief History of Its Emergence and Evolution, J. Eur. Ceram. Soc. 2009, 29, 223-236.

4. Podsiadlo, P., Kaushik, A. K., Arruda, E. M., Waas, A. M., Shim, B. S., Xu, J., Nandivada, H., Pumplin, B. G., Lahann, J., Ramamoorthy, A., Kotov, N. A., Ultrastrong and Stiff Layered Polymer Nanocomposites, Science, 2007, 318, 80-83.

5. Mamedov, A. A., Kotov, N. A., Prato, M., Guldi, D., Wicksted, J. P., Hirsch, A., Molecular Design of Strong SWNT/Polyelectrolyte Multi layers Composites, Nature Materials, 2002, 1, 190–194.

KEYWORDS: Ultra strong materials, Nano composites, Layer-by-Layer assembly, transparent armor materials, nanoclay materials.

A10-124 TITLE: Lithium Ion Batteries with Wide Operating Temperature Range

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Increase the operational temperature range of prismatic laminate lithium ion battery cells through electolyte and materials improvements which allows transition of these batteries to Army ground vehicles without the overhead of specialized heating and cooling systems.

DESCRIPTION: Lithium ion battery cells can be designed to operate in a variety of temperature ranges. However, the width of the operational temperature range can be a limiting factor for military applications, which require operation in environments from -50 deg C to 70 deg C. At low temperatures the electrolyte becomes more viscous and resistance is increased, resulting in poor battery performance. At high temperatures electrolyte can become unstable and participate in side reactions with other battery components, such as the electrode active materials. Additionally, at high temperatures cell components such as the separator may melt, causing cell failure. Finally, the prismatic laminate type cell is of particular interest to the Army because of its potential for dual-use application in both military and commercial automotive vehicles. This cell design is advantageous in commercial vehicle applications because it can accommodate large capacities and is scalable for a variety of battery pack configurations. As a result, many automotive companies are moving to prismatic laminate cells for their hybrid and electric vehicle applications. The Army wishes to leverage the market for these cells for military vehicle applications. However, at high temperatures this cell type suffers from an additional failure mode because the cell packaging can melt.

To this end, the Army is soliciting proposals to research and develop new lithium ion prismatic laminate cells capable of operating in a temperature range of -50 deg C to 70 deg C. Proposals should address the capability of both the external packaging materials and internal components (electrolyte, separator) to operate at this temperature range. The newly developed cells should exhibit a minimum cycle life of 300 cycles at both the high and low temperature extremes and have performance characteristics similar to typical lithium ion cells at room temperature. Further, at low temperatures, the cells should exhibit capacities of at least 50 percent of their rated capacity.

PHASE I: Develop and demonstrate electrolytes, materials, and/or packaging techniques to allow wide operational temperature range in lithium ion prismatic laminate cells. Perform feasibility testing on commercial format cells to show cell operation in the extended temperature range. Results of the research and testing shall be provided in report form as deliverables for Phase I.

PHASE II: Produce several prototype prismatic laminate cells of at least 10 Ah capacity each. Integrate the cells into a 6T size battery pack with a battery management system to demonstrate their applicability to military platforms. Results of the development effort and testing shall be provided in report form as deliverables. Additionally, cells and packs produced under the effort shall be delivered to the Army for independent evaluation.

PHASE III: The resulting technology will feed into the non-primary power system ATO to develop advanced batteries suitable to be integrated into current Army ground vehicle platforms. It will also enable increased performance of commercial hybrid electric vehicles. Markets for the technology include Military Vehicle OEMs, battery manufacturers, and commercial hybrid electric vehicle OEMs.

REFERENCES:
1. T. R. Jow, M. S. Ding, K. Xu, S. S. Zhang, J. L. Allen, K. Amine and G. L. Henriksen, “Nonaqueous electrolytes for wide-temperature-range operation of Li-ion cells“, J. Power Sources, 119-121(2003)343.

2. M.C. Smart, B.V. Ratnakumar, and L. D. Whitcanack, “Assessment of Various Low Temperature Electrolytes in Prototype Li-ion Cells Developed for ESMD Applications”, 6th International Energy Conversion Engineering Conference (IECEC), 28 - 30 July 2008, Cleveland, Ohio.

3. Thanthrimudalige D. J., Dunstan, Josip Caja, “Lithium-ion cell with a wide operating temperature range”, US Patent 7582380.

KEYWORDS: lithium ion, batteries, electrolyte, separator, packaging, temperature range

A10-125 TITLE: Plug & Play Integrated Hybrid Power System for Humanoid Robot

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

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

OBJECTIVE: This SBIR is to develop a small, light weight, integrated hybrid electric power system with a standard control interface, to power a 400 to 500 pound class robot, fueled by either JP-8 or propane.

DESCRIPTION: Currently, no single power source system (e.g., battery pack, fuel cell, engine) meets the stringent robotic vehicle mission performance requirements for mission duration and for power source weight, space claim, and environmental packaging, plus robot system, subsystem and payload power demands. The Army needs a small, light weight, integrated hybrid electric power system (e.g. fuel cell or combustion engine, coupled to a high power output electrical energy storage system) to supply both a specified average current, and short burst power requirements.

The integrated power system should have a standard control & supply interface for ease of installation and cross-platform operational compatibility. The power system should communicate with the robot control system over an industry standard protocol (IIC/SMB, CANbus, USB, RS232, RS485, Firewire, or Ethernet). It should provide up to 12 hours endurance before refueling, for a 400 to 500 pound humanoid robot. The humanoid robot is capable of lifting and carrying a 400 pound payload (i.e., 800 pound gross vehicle weight) using two hydraulically driven manipulators and driving at human-like speeds over both flat and rugged terrains (i.e., the robot operates with and where soldiers go). The hydraulic pump will be electrically powered by the hybrid power system.

The integrated power system volume should be 1000 cubic inches or less, with at one dimension not to exceed 7 inches. The power system must provide a nominal 180V DC, with a maximum current of 120A, minimum average current of 20A, and desired average current of 30A. Maximum weight for the integrated power system should not exceed 60 pounds, with a desired target of 30 pounds, including fuel, should be included in the integrated power system weight and volume budgets. The preferred fuels are JP-8 or propane. The integrated power system must be packaged to survive and operate in environments where soldiers perform (i.e., self temperature regulated and Ingress Protected IP67 per IEC 60529). Noise level of the integrated power system should be lower than 50 db at 20 feet.

The integrated power system should be capable of operating in any orientation and be able to withstand the robot movement, shock, and vibration.

PHASE I: A benchtop / breadboard demonstrator of the proposed integrated hybrid power system shall be designed, developed and demonstrated to verify feasibility of meeting the stringent robotic vehicle mission performance requirements. Based on the benchtop system design concept, market research will be conducted and documented to identify subsystem, off-the-shelf components (e.g., fuel cell or engine, battery packs, capacitors), that could be integrated as a hybrid power system to meet the design requirements. A preliminary design of the integrated hybrid power system's control electronics, and control interface to the robot central processor unit will be included with the market research documentation.

PHASE II: Based on Phase I preliminary design documentation, the integrated hybrid power system will be fully designed, developed, tested and delivered to the government, along with final design and interface control documentation. The contractor will provide manpower, materials and travel to support government operational verification tests of the integrated hybrid power system.

PHASE III: The power source will apply to robots weighing several hundred pounds which require more operating endurance than batteries alone can provide. The BEAR robot is one example. It will also be a likely candidate to power manned exoskeleton machines used for material handling, mining, law enforcement, rescue and possibly combat assault. Exoskeleton machines and similarly-sized robots will have a range of parallel applications in military, civil and some commercial uses.

REFERENCES:
1. Marc Raibert, Kevin Blankespoor, Gabriel Nelson, Rob Playter and the BigDog Team, "BigDog, the Rough-Terrain Quaduped Robot", Web article, Boston Dynamics, Waltham, MA 02451

2. Eric Lesp´erance, Alexis Lussier Desbiens, Marc-Andr´e Roux, Marc-Andr´e Lavoie and Philippe Fauteux, "Design of a Small and Low-Cost Power Management Unit for a Cockroach-Like Running Robot", Universit´e de Sherbrooke, Sherbrooke (Qu´ebec, Canada)

3. Ching-Kuo Wang, Wei-Fu Huang, and Jane-Ferng Chiu, "Intelligent Power Management of Lithium-Ferro-Phosphate cells on the Homecare Robot", 2009 IEEE/ASME International Conference on Advanced Intelligent Mechatronics Suntec Convention and Exhibition Center, Singapore, July 14-17, 2009

4. Clarification from TPOC of BEAR Robot Power Requirements. (Uploaded in SITIS 6/2/10)

KEYWORDS: hybrid electric power, small engines, JP-8, propane, robot power, heavy fuel engine, power electronics

A10-126 TITLE: Reduction of vehicle display-induced motion sickness

TECHNOLOGY AREAS: Information Systems, Biomedical, Human Systems

ACQUISITION PROGRAM: PEO Integration

OBJECTIVE: The objective of this program is to develop innovative approaches that will reduce vehicle display-induced motion sickness in order to improve indirect vision driving performance at the closed hatched mode and warfighter's C2 operation, robot tele-operation, or on-board training in a moving combat vehicle.

DESCRIPTION: The US Army combat vehicles maneuver in indirect-vision driving (IVD) mode for warfighter survivability when external threats are active. While moving in the combat vehicles, soldiers are required to perform such cognitive performance as: Battle Command, Command and Control (C2), robotic system control, and/or on-board training.

Past research reports that 55% of soldiers had moderate to severe motion sickness in the moving C2 vehicle and 37% were functionally incapacitated. Indirect vision driving a HMMWV caused a 20-33% decrease in speed, 120-229% increase in driving errors, and 20% of drivers were unable to complete the task because of motion sickness [1, 2]. Research has also identified motion sickness-type symptoms as being caused by computer displays [3, 4]. In a user test in a moving amphibious assault vehicle in which Marines were working at computer workstations, many of the participants reported moderate to severe motion sickness symptoms during or after their computer usage. In a test of Soldier performance in a modified M113, cognitive task performance was less accurate (7 to 47% less) and slower (7 to 40% slower) than during moving operations [5].

The literature revealed possible causal factors and types for the computer display-induced motion sickness, and suggested remedies to reduce its symptoms and related performance decrements. Demographic factors that may influence motion sickness susceptibility are gender, exposure history, receptivity, adaptability, and personality characteristics. The primary theory of display-induced motion sickness is that of sensory conflicts between the visual information on the computer screen and vestibular perception of vehicle motion.

Previous works revealed several potential motion sickness prevention methods. The operator's seat should be designed to offer head restraint to limit independent head movement. During design, consideration should also be given to wave frequency in vertical periodic motion. It was determined that sickness incidence diminishes with increasing frequency above 0.6 Hz. Another potential area of consideration is perceptual adaptation through prior exposure or training session. Many researchers used motion sickness history questionnaires (MSHQ) as a means to predict susceptibility. However, these methods are not considered in this SBIR topic.

Another possible method is to mitigate visual sensory conflicts by bringing visual and vestibular cues into alignment through display resolution, Field of View (FOV), image stabilization, and system lag reduction. The impact that improved resolution or wide versus narrow FOV has on motion sickness is unclear. However, it is suggested that motion sickness symptoms increase with system lag. The system lag and image stabilization weigh heavily with combat vehicles' use of multiple displays. We can consider to apply ortho-stereoscopic display technology in order to provide the driver with the naturalistic view of the outside scenery as if he/she is looking through real vehicle window. To reflect the driver's head motion on the display imagery, we may use a virtual window concept for the vehicle display. In this method, the display system tracks the head movement and adjusts the display view dynamically in response to the head motion.

This SBIR research solicits industry involvement in finding the methods to mitigate the vehicle display-induced motion sickness, and in determining vehicle display system design specifications to mitigate its symptoms. For the vehicle driver, we speculate that reduction of display-induced motion sickness can be made through but not limited to alignment of visual and vestibular signals, by providing stabilized video, reducing visual signal latency, and/or providing naturalistic view via ortho-stereoscopic display that dynamically adjusts head motion. For the crew members who conduct C2 operation, robot tele-operation, or on-board training in the moving vehicle, motion sickness may be reduced if a reference frame is provided on the display to help them comprehend vehicle motion.

The proposed program should address the IVD motion sickness to the vehicle driver through the following specifications: 1) Camera provides stabilized visual images with the aid of a gyroscope, 2) Video latency from camera to display is less than 80 ms, 3) Suggested methods are demonstrated to be effective in reducing the display-induced motion sickness, and 4) Other causes of visually induced motion sickness are identified and resolved, contributing to reduction of overall motion sickness. It also should address the display-induced motion sickness to the crew members who conduct C2 operation, robot tele-operation, or on-board training, through the following specifications: 1) Causes of crew cognitive performance degradation from display-induced motion sickness are identified and resolved, and 2) Suggested methods are demonstrated to be effective in reducing the display-induced motion sickness.

PHASE I: Phase I effort focuses on the feasibility study and system design to reduce the display-induced motion sickness. It includes fata collection from other evaluations, display system design, evaluation methodology development, and evaluation measures that can be implemented in field environments and operational environments. Display system should be designed to provide stabilized visual images with the aid of a gyroscope, and video latency from camera to display less than 80 ms. Evaluation methodology development should include: indirect vision driving, C2 operation, and UGV control in a moving HMMWV. Evaluation measures should include severity of operation sickness, level of cognition/decision making/situational awareness and understanding, and time and accuracy of task completion.

PHASE II: In Phase II, the program is anticipated to fabricate the display system in accordance with Phase I system design. Using the display system, the program evaluates the display system design concept by utilizing a ride motion simulator per Phase I evaluation methodology. Upon positive simulation result, the program continues to evaluate the warfighter's cognitive performance on the moving surrogate vehicle (eg., HMMWV). A detailed technical reports shall include Design Guidelines for ground combat vehicle material developers and methods for testing motion effects in research and operation. Design Guidelines for combat vehicle material developers should include: Vehicle and Workstation Guidance, C4ISR equipment guidance, Visual display mitigation techniques, and Input:Output device. In addition, the Phase II program shall deliver the fabricated display system.

PHASE III: During Phase III, the program shall develop the display system integration with a military vehicle (eg., prototype Ground Combat Vehicle) to experiment indirect vision driving and C2 operation performance on the moving vehicle. The program shall also develop commercial transition partners for applications such as advance vehicles, training, and simulation.

REFERENCES:
1. Tauson, R., Doss, N., Rice, D., Tyrol, D., Davidson, D. (1995). The Effect of Vehicle Noise and Vibration (Caused by Moving Operations) on Cognitive Performance in the Command and Control Vehicle (ARL-MR-279). Aberdeen Proving Ground, MD: U.S. Army Research Laboratory.

2. Cowings, P., Toscano, W., DeRoshia, C., & Tauson, R. (1999). Effects of command and control vehicle (C2V) operational environment on Soldier health and performance. NASA-TM-1999-208786. National Aeronautics and Space Administration, Ames Research Center, Moffet Field, CA.

3. Cobb, S., Nichols, S., Ramsey, A. Wilson, J. (1999). Virtual reality-induced symptoms and effects (VRISE), Presence, 8(2), 169-186.

4. Kennedy, R., Stanney, K., and Dunlap, W. (2000). Duration and exposure to virtual environments: Sickness curves during and across sessions. Presence, 9(5), 463-472.

5. Schipani, S., Bruno, R., Lattin, M., King, B., and Patton, D. (1998). Quantification of Cognitive Process Degradation While Mobile, Attributable to the Environmental Stressors Endurance, Vibration, and Noise (ARL-TR-1603). Army Research Laboratory, Aberdeen Proving Ground, MD.

6. Susan G. Hill and Richard A. Tauson, Soldier Performance Issues in C2 “On the Move.” (ARL-MR-074, 2005). Aberdeen Proving Ground, MD: US Army Research Laboratory.

7. Patricia M. Burcham, Motion Sickness Literature Search. (ARL-MR-504, May 2002). Aberdeen Proving Ground, MD: US Army Research Laboratory.

8. Herschel W. Leibowittz, et al. Motion Sickness, Visual Displays, and Armored Vehicle Design. National Research Council Committee on Vision and Working Group on Wraparound Visual Displays. Conference on Wraparound Visual Displays, January 14 – 15, 1988, Brandeis University, Waltham, Massachusetts.

9. Additional Q&A from TPOC in response to FAQs for SBIR Topic A10-126. Uploaded in SITIS 5/14/10.

10. Additional Q&A from TPOC in response to FAQs for SBIR Topic A10-126.
Uploaded in SITIS 5/21/10.

KEYWORDS: Motion sickness, Command and Control (C2) on the move, indirect vision driving, video latency, video stabilization.

A10-127 TITLE: Advanced Materials and Manufacturing for Lightweight, Low Cost Seeker Gimbals

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 innovative materials and associated manufacturing processes for high volume production of lightweight, low cost, precision seeker gimbal assemblies that can operate in military aviation environments inducing high stress levels, i.e., temperature, vibration and shock as documented in MIL-STD-810 and including an environmental temperature range of -55 C to +85 C. Gimbals should have a capability of maintaining less than 4 miliradians pointing accuracy, greater than 60 degrees per second slew rate, and less than 25 microradians rms stabilization.

DESCRIPTION: The Program Executive Office, Missiles and Space (PEO MS) has application for materials and manufacturing processes for lightweight, low cost gimbals. Gimbal mechanisms are used in several diverse missile assemblies, to include gyros, thrust vector control systems and missile seekers. The PEO MS is proposing a SBIR project to investigate the application of innovative materials and manufacturing processes for lightweight, low cost seeker gimbals. Innovative materials and manufacturing processes can be from any of the major material types as long as they provide lightweight and low cost in addition to being able to withstand the relevant environments. Innovative manufacturing processes can be from any of the process types to include powder technology, forging, casting, etc. Net-shape or near-net-shape processes are of particular interest. Assembly processes should consider semi-automated and fully automated assembly. The emphasis will be on alternative materials and manufacturing processes to demonstrate innovative means to produce lightweight, low cost gimbals. Baseline performance information can be obtained by the SBIR contractor via written request to the Technical Points of Contacts.

This effort is to focus upon, as a minimum, investigating potential materials and manufacturing processes to design and build 3-6 prototype gimbals with the associated optimized manufacturing and assembly techniques.

A realistic production unit cost would not exceed $600-$1200 per gimbal assembly for a seeker gimbal assembly based on expectations for 20,000 to 30,000 gimbals. The cost metric is expected to be achieved while maintaining performance and quality of the gimbal.

A further goal is to reduce parts count by integrating separate components into integral subassemblies. For example, brackets, clamps, wire ties, and other small parts could be formed by a number of processes. Reduction of fasteners by using existing components is another possible means to reduce cost. An increase in ruggedness and sparing costs are valuable results of simplification.

Developing Flexible Manufacturing Cells (FMCs) is a means to reduce manufacturing costs by lowering direct labor cost and minimizing scrap, re-work, and material waste. The benefits include: less skilled labor, reduction in work-in-process (WIP) inventory by eliminating the need for batch processing, reduction in production lead time, permitting manufacturers to respond more quickly to the variability of demand, and improved process control, resulting in consistent quality. A FMC could consist of CNC machines, a cell computer, a robot, etc.

Deviation in the basic design of the gimbals from existing practice, and from existing materials (generally aluminum and steel) is acceptable. There are no limitations on materials if they can meet the environmental requirements.

PHASE I: Investigate alternative gimbal materials and manufacturing processes to produce a low cost, lightweight gimbal capable of withstanding high stress environments. Provide down selection criteria based on reduced cost and weight. Provide as a deliverable an analysis to support recommendation of the most appropriate materials and manufacturing processes for further evaluation in Phase II.

PHASE II: Since it isn't possible to build large quantities of assemblies on SBIR funding, nor appropriate for a research and development contract, the contractor should provide feasibility assessments of the proposed solution by building a work cell, developing processes, and producing 3-6 gimbals with the work cell equipment with the goal of demonstrating that the proposed material/manufacturing processes represents a feasible approach. Inspect gimbals for any defects and adherence to manufacturing tolerances. This effort will produce information on the producibility, repeatability, estimated production time, estimated yield, and labor hours of the proposed process. The contractor should provide a lessons learned summary about the results and a manufacturing tolerance study. Provide the gimbals to PEO MS personnel as needed for performance and environmental evaluation and testing.

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 commercial space satellite industry and the commercial aircraft cockpit avionics industries. Manufacturing Readiness Levels should mature to MRL 7-8 in this phase.

REFERENCES:
1. www.southernresearch.org/pdf/gimbals.pdf

2. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Groover, Wiley, 2006

3. Manufacturing Engineering Handbook, Geng and Geng, Mc Graw-Hill, 2004

4. Advanced Machining Technology Handbook, Brown, Mc Graw-Hill, 1998

5. Flexible Manufacturing Cells and Systems, Luggen, Prentice Hall, 1991

6. Manufacturing Readiness Levels - http://www.dodmrl.com

7. www.dtic.army.mil/pdf/810.pdf. for general test methods and procedures, MIL STD 810G temperature range from -65°F to 165°F. Method 513.5 (Acceleration), Structural Test for aircraft/helicopters/Aircraft stores and Method 514.5 Categories 12-19 (Vibration) and Method 515 (Shock)

KEYWORDS: Gimbals, FMC, net-shape, robotic

A10-128 TITLE: Missile Based Deployment System

TECHNOLOGY AREAS: Air Platform, 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 effort is to develop an innovative low cost missile-deployed device/platform capable of carrying Army Enterprise equipment, herein called the payload, for a specific time period at approximate altitude(s) and position. The deployment must be achieved with and without GPS assistance.

DESCRIPTION: Battlefield commanders are increasingly dependent on real time information for communications and situational awareness. With all these data streams being exchanged within the battle space, the need to increase the level of exchange while reducing the complexity of the exchanges is desirable, so a proposed solution is a low altitude disposable satellite-type device.

The device envisioned, would be used as a retro-fit payload for deployed munitions systems. The initial concept rockets for design and testing include the ATACMS or XM31/M30 GMLRS missiles. The concept of operation is that the payload, such as a communications package, would be attached to the proposed device/platform and slipped into the warhead bay of a rocket and be launched at a point above the battle field where a short term stationary platform is required. Some type of hover or floating technology would be released at the desired point after separation from the missile and should be capable of supporting a variety of desired Army Enterprise equipment payloads.

The technical challenges for this effort include:

1. Developing the release mechanism for the technology that would allow the Army Enterprise equipment to hover or float over the battlefield.
2. Developing the mechanism for deploying the hover or floating technology while it is in freefall.
3. Overcoming the challenges of the earth's atmosphere to deploy a tropospheric micro-satellite-type device.

The desired payload specifications are made if a GMLRS body is used:
1. Total weight including payload <200lbs
2. Payload weight 50-100lbs
3. Undeployed diameter less than 7.5"
4. Undeployed length less than 3'
5. Platform on station 2 hours, assuming no damage
6. Deployable altitude +10,000 feet AGL

Alternate designs using ATACMS flight capabilities or other deployed Army missile systems will be considered. The system should be able to sense when it is at the proper position with and without GPS guidance and be able to act independently of the missile's on-board navigational package to disperse the balloon package.

PHASE I: Design and determine the feasibility of launching the proposed technology using a GMLRS or ATACM missile system and deploying the platform at a predetermine position. At deployment, this device will need the capabilities to support whatever payload is attached, so adherence to the above specifications is critical. A desired, but not required, feature would be designs that mitigate the effects of wind at altitude. This could include low wind profile designs or active stabilization.

PHASE II: Build a prototype device fully capable for testing in a static test environment. This should be the results from the Phase I development with only improvement modifications.

PHASE III: The final product will be an air platform capable of carrying the desired payload, such as NET communication and/or situational awareness equipment, to not only the Army ground forces, but also transition/transfer to the Department of Homeland Defense, or other First Responders, where there is a need for a temporary satellite-like platforms, such as for assessing/supporting: forest fires, large scale search and recues, or other public events. Alternately, this product could be used by universities to conduct low cost scientific experiments.

REFERENCES:
1. http://www.deagel.com/Rockets/M31-GUMLRS_a001107002.aspx

2. http://www.astronautix.com/lvs/mlrs.htm

3. http://en.wikipedia.org/wiki/MGM-140_ATACMS

4. http://www.fas.org/man/dod-101/sys/land/atacms.html

KEYWORDS: MLRS, ATACMS, pseudo-microsatellite

A10-129 TITLE: MTBI Protective Mandibular Appliance

TECHNOLOGY AREAS: Materials/Processes, Biomedical

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

OBJECTIVE: Develop a Protective Mandibular Appliance that can be used by Warfighters to reduce shock and concussive injuries which will ultimately reduce facial and head injuries while minimizing Mild Traumatic Brain Injuries (MTBI).

DESCRIPTION: The Army is investigating means to reduce concussive forces originating from impacts associated with high energy events. Currently, soldiers wear protective systems to protect against blast, blunt and ballistic threats for multiple operational missions. Body armor and headborne protective systems serve the individual soldier platform against a variety of battlefield threats. However, facial protection for soldier missions is limited to protective eye wear, goggles, and helmet shields for Explosive Ordnance Disposal operations. Due to increased IED attacks, soldiers are experiencing increased facial and jaw injuries from these blasts with concussions and potentially mTBI being observed. While the specific cause of concussions is part of ongoing medical research efforts; facial and skull injuries experienced by soldiers can be reduced with the use of an appliance device which helps reduce concussion risks and protects the face and jaw.

Currently, professional sports athletes are fitted with a customized dental appliance to help decrease concussive forces being exposed to the head and jaw regions in violent impact circumstances. However, this athlete type appliance would not be applicable for an individual soldiers being is exposed to extreme levels of complex blast effects occurring in microseconds. Nevertheless, a soldier could make use of an innovative solution to prevent facial injuries and reduce event related mTBI where battlefield high energy IED events produce much greater magnitudes of concussive impact forces and blast wind over pressures impulses which may cause debris penetration and blunt trauma concussive injuries. Research on this appliance, indicates a relationship between the jaw and skull at the temporomandibular joint (TMJ) that better enables players to dissipate the force that originates from a violent blow to the chin. Without the shock absorber in place, a concussion and/or other neurological damage can occur when the jaw slams into the skull.1 In addition, a peer review hypothesis presented by Massachusetts General Hospital/ Harvard School of Dental Medicine Oral Maxillofacial Surgery Department indicated that “tight helmet chin strap worn by troops places increased pressure on the temporomandibular joint with the result of enhanced force transmission and/or decreased resistance within the cervical musculature to oblique forces to the head 2 ”. The thrust of this research effort is to develop an innovative appliance system for soldiers to wear as an orthotic type splint and mouth guard that will absorb and dissipate high energies due to blast over pressures or blunt impacts being exposed to the skull and TMJ region while protecting the soldier jaw and teeth.

The objective will be develop an innovative appliance solution and identify materials that are light, comfortable, and compatible with all applicable Federal Drug Agency (FDA) requirements for soldiers to wear in their mouths in a wide variety of environmental and combat conditions. This material system shall be capable of absorbing and/or dissipating high energy impacts under the influence of forces and loads at blunt impact velocities ranging from 10-17 ft/s and high energy positive peak pressures impulses ranging from 300 to 600 KPA ms for over pressure durations between 1-6 ms. The finished appliance will be designed as so to be integrated with the soldier platform and shall not interfere with any other equipment, components and accessories such as chin straps and communication devices. The appliance when utilized shall demonstrate a measured performance capability which limits direct translation and general motion impact accelerations less than 150 G’s.

PHASE I: Research and develop a solution which have a potential to reduce impact energies translated to a soldier TMJ and skull. Comparative modeling and simulation testing shall be performed on the existing appliance systems, mouth guards and new candidate materials designs to demonstrate the magnitude of improvements and repeatability of the materials behavior when subjected to multiple impacts conditions. This research effort will determine whether the customized mandibular orthotic appliance reduces the incidence of concussion and mild traumatic brain injuries for a wide range dynamical impact conditions. This Phase I effort would lead towards developing material processes and recommendations for manufacturing techniques towards the production of a finished item. Deliver a report documenting the research of the material system, modeling and simulation results and its dynamic energy absorption and dissipation criteria established based on the overall appliance performance.

PHASE II: Develop the material system and the processing technology identified in Phase I. Fabricate sufficient samples for extensive shock tube and impact testing with the new appliances being fitted to individual soldiers. Perform shock tube testing with appliance fitted into an appropriate sized bio-fidelic mandible joint as part of a Facial and Ocular Countermeasures Safety (FOCUS) headform. The FOCUS shall be instrumented with reference sensors capable of measuring impact loads to the face and TMJ region. Shock tube and blunt impact testing methodologies will be provided by the government to baseline the over-pressure and high energy loading parameters. Test results shall demonstrate that peak translational and rotational accelerations below 150 G's experienced at the TMJ region for a wide range of blast and impact conditions.

The government will specify multiple size configurations for the appliance being installed into a FOCUS. Perform a human factors test to ensure that the materials are approved from oral usage, as well as being comfortable and feasible in simulated combat environments. Tests performed must include specially designed physical human head models which closely match the size of human's skull and cranial bone for an average male and equivalent medical standard to obtain biomechanical data which correlates to impact behavior protection. Additional TMJ assessments techniques such as Stereomicroscope tool shall be used to demonstrate the proper fitting of the appliance and assist the bio-mechanical pre-assessment to support conclusive test results and findings.

The human factors assessments must validate and demonstrate that the appliance reduces concussions. The Automated Neuropsychological Assessment Metrics (ANAM) battery test will be used to correlate any significant test findings on whether human subjects with and with self reported previous concussions or mTBI showed any through put difference when wearing the appliance on any ANAM subtest. 3 Overall testing results shall demonstrate that dental trauma will be reduced when a human subject is wearing the appliance. Deliver a report with prototypes documenting the research the development efforts along with a detailed description of the proposed material systems and their overall performance as so to improve head and facial protection and reduce event related MBTI. Proposed exit criteria – Technology Readiness Level (TRL) 4.

PHASE III: Upon successful completion of the research and development in Phase I and Phase II, the Protective Mandibular Appliance will be manufactured and deployed for individual field use. A new protective mandible splint or appliances would be applicable for both military and civilian applications. Professional and amateur sport venues such as boxing, football, lacrosse and hockey, as well as other physical activities or recreational sports where high impacts could occur would also be able reap as substantial benefit to use this technology. Proposed exit criteria – TRL 7.

REFERENCES:

1. Kram, M., (August 2009) "Dental Device Helps Reduce Concussions Risk for Athletes", Philadelphia Daily News, http://philly.com/philly/hp/sports/20090825

2. Shaefer, J. " AAOP Peer Review", Massachusetts General Hospital, Harvard School of Dental Medicine Oral Maxillofacial Surgery Department. (2009)

3. Reeves, D., "Reference Values for performance on the Automated Neuropsychological Assessment Metrics V3.0 in an Active Duty Military Sample", Military Medicine, Vol. 171, October 2006.

4. Singh, D., Maher, G., Padilla, R., "Customized Orthotics in the Prevention of Concussions/Mild Traumatic Brain Injury in Football Players: A Preliminary Study", Dental Traumatolgy, July 2009.

5. Walilko, T., Biomechanical Responses of the Temporo-Mandibular Joint from Impacts in Boxing", Engineering, Biomedical Health Sciences, Rehabilitation and Therapy, (2004)

6. Gusenbauer, A., "Brain Injury in Sports Related to Trauma to the Lower Jaw", Sports Dentistry, December 2002.

7. Okie, S. (2005) “Traumatic Brain Injury in the War Zone,” New England Journal of Medicine, Vol. 352, pp. 2043-2047.

8. Rigby, P.H. and Chan, P. (2008) “Evaluation of Biofidelity of FMVSS No. 218 Injury Criteria”, Technical Report for Human Injury Research Division, NHTSA, DOT. Accepted to appear in Journal of Traffic Injury Prevention.

9. Halstead PD., “The Role of Intraoral Protective Appliances in the Reduction of Mild Traumatic Brain Injury.” Compendium Vol 30 (Special Issue 2) July/aug 2009. pp. 18-20.

10. Takeda T, Ishigami K, Hoshina S, Ogawa T, Handa J, Nakajima K, Shimada A, Nakajima T, Regner CW., “Can Mouth guards Prevent Mandibular Bone Fractures and Concussions ? A Laboratory Study with an Artificial Skull Model”, Dental Traumatol 2005; 21, pp 134-140.

KEYWORDS: Mild Traumatic Brain Injury, Temporo-Mandibular Joint, Stereomicroscope, Shock Tube, Impact Protection, Blast Over Pressure

A10-130 TITLE: USB Firewall for Direct Connect USB Cyber Warfare Protection

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this effort is to develop a compact USB firewall that can be used to protect government computer systems from Cyber Warfare attacks using common USB devices. The device should enforce the USB standards for devices attached to a computer system, and prevent the devices from performing malicious acts.

DESCRIPTION: USB is a widely-used interface mechanism in the modern computer industry for peripheral devices (USB can also be used to directly inter-connect computers). While widely used, it is often not understood both by the developer and the security expert. In its basic form, USB forms an extension of the computer’s internal hardware structure/memory to the outside world.

To begin to understand the complexity of USB, one must first define what USB is and how it interconnects computers and the external hardware devices. One of the simplest ways of abstracting the interconnect methodology is to view each separate device as an independent entity/computer that is interconnected in a client-server fashion to the central host. Each node on this quasi-network has its own firewall (the USB hardware layer), and under the USB specifications, each node is assumed to follow the documented procedures.

The network analogy goes very deep inside the core of how both USB and Firewire are designed. Under USB, each device has its own distinct address assigned by the host computer as per USB specification. This is highly analogous to the IP address used in modern networking. In addition, each USB device can have up to 9 endpoints, which are similar in function to the port on a networked computer. Two of these endpoints are designed in a specific way. Endpoint 0 is a bi-directional endpoint that is used exclusively for control of the USB device. It is used by the host to set basic features and other host client signaling. Endpoint 1 is also a bi-directional endpoint with a data buffer of a fixed size. Both of these endpoints are always defined. The other endpoints are mono-directional and of variable size and may not exist.

The specifications of the interface force this kind of structure, and what each controls varies between manufacturers. What is important to note is that unlike older peripheral interfaces (such as RS-232C), a significant amount of USB functionality is embedded in specialized hardware that is not easily accessible or directly controlled by typical equipment manufacturers.

This creates an environment where the device, that is a trusted agent, comes from an untrusted source. There are a number of potential vulnerabilities due to malicious USB devices. These include:
1. Malicious code on storage
2. Storage bait-and-switch
3. Monitoring devices
4. Data leaks across device boundaries
5. Keyboard/mouse emulation
6. Remote control
7. Electronic Attack devices

Required for this initiative is the development and construction of an inexpensive "USB Firewall" which would act as an intermediary between the on board USB bus and the device to be connected. This device would act as a trusted filter to detect/mitigate malicious activity and hard electronic attack.

PHASE I: Conduct analytical and experimental efforts to demonstrate feasibility of designing a USB firewall which can detect and defend against malicious activity. Proof-of-principle experiments with a brass board device would be encouraged to determine the feasibility of such a device.

PHASE II: Based on the results and findings of Phase I, demonstrate the technology by fabricating and testing a prototype in a laboratory environment. Assemble a proof-of-principle device and demonstrate the proposed technology and its ability to signal an attack warning, identify its characteristics, and defend against the attack. Identify and address technological hurdles. The proposed development and demonstration should be limited to what is required to demonstrate TRL level 4 or level 5 and should identify the means necessary to transition the technology.

PHASE III: This technology could be used in a broad range of military and commercial applications. The final embodiment of this device would be a standalone hardware module where un trusted USB devices could be inserted to minimize damage/virus injection possibilities. The final device should result in a standalone self updatable unit that can be self installed by any user. It should warn the user of possible threat via either on screen message or status lights and require minimal configuration and maintenance.

REFERENCES:
1. http://people.omnigroup.com/wiml/soft/pic/keyspan.html

2. On-the-Go Supplement to the USB 2.0 Specification, Revision 1.0a, June 24, 2003

3. USB Specification, Revision 2.0, April 27, 2000

4. Axelson, Jan, USB Complete, 3rd ed., Lakeview Research, 2005

5. Wheeler et al. Prototyping Trusted Path on Virtual Machine Architectures. 2006. IDA paper P-4110.

KEYWORDS: USB, Cyber warfare, Firewall

A10-131 TITLE: <u>Compact Efficient Electrically Small Broadband Antennas</u>

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: The objective of this effort is to develop ultra compact efficient electrically small broadband antennas capable of handling high voltages.

DESCRIPTION: The US Army has programs that require very compact electrically small antennas that are capable of handling high voltages; i.e., greater than 100 kV. The wavelengths that antennas radiate efficiently are determined by the dimensions of the antenna. Electrically small antennas are antennas that radiate signals having wavelengths greater than the dimensions of the antenna. For example a lambda/10 antenna, where lambda is the wavelength, is one that radiates wavelengths that are 10 times longer than the characteristic dimensions of the antenna. These antennas need to be robust in that they must be capable of handling very high voltages and high g-forces. The cell phone companies have developed electrically small antennas, but they are not efficient and cannot handle high powers. However, it may be possible to leverage some of their developments. The most recent advances in electrically small antennas have been based on the development of new materials and geometric configurations; e.g., fractal structures. The Army is seeking innovative approaches for developing efficient electrically small broadband antennas. The antennas currently of interest must fit into small geometrical spaces; i.e., less than 1.5 inches (40 mm) in diameter and 2 inches (50) mm in length.

PHASE I: Develop electrically small broadband antennas and conduct proof-of-principle demonstrations to verify that these antennas can efficiently radiate frequencies of interest (20 MHz - 1 GHz), can withstand high voltages (> 100 kV), and can meet the volume constraints (40 mm diameter, 50 mm length.

PHASE II: Based on the results of Phase I, continue to develop efficient electrically small antennas by exploring new materials such as nano-materials and meta-materials and by assessing environmental effects these antennas may be prone to. Work with the munitions developers to ensure that the antennas can meet the form factor requirements of their respective munitions and that the antennas can withstand g-forces as high as 50,000 g's. Verify that the antennas still radiate efficiently in the frequency band from 20 MHz to 1 GHz when incorporated into munitions. Identify issues associated with manufacturing the antennas.

PHASE III: There are many military and commercial uses for antennas including communications, radars, and various sensors. In particular, the results of this effort will be of interest to cell phone companies, which are continuing to fund the development of electrically small antennas. Likewise, there are many military platforms that require compact broadband antennas including UAVs, missiles, munitions of various types, and satellites. If successful, the most immediate transition path is the delivery of a new class of munitions to PEO Ammo.

REFERENCES:
1. J.D. Kraus, Antennas, McGraw-Hill Book Company (1950).

2. R.A. Cairns and A.D.R. Phelps, Generation and Application of High Power Microwaves, Taylor and Francis (1997).

3. D.V. Giri, High-Power Electromagnetic Radiators: Nonlethal Weapons and Other Applications, IEEE Press (2001).

4. R.J. Barker and E. Schamiloglu, High-Power Microwave Sources and Technologies, Wiley-IEEE (2001).

5. J. Benford, J.A. Swegle, and E. Schamiloglu, High Power Microwaves, 2nd Edition, CRC Press (2007).

KEYWORDS: Antenna, Switch, High Voltage, Electrical Breakdown, Effective Radiated Power

A10-132 TITLE: High Temperature Silicon Carbide (SiC) Gate Driver

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: This topic will develop and demonstrate compact, high frequency, high temperature silicon carbide (SiC) gate driver modules to control high temperature SiC transistor power modules. The use of SiC gate drivers will enable the use of SiC power electronics at their full ratings and temperature. Gate driver modules must operate reliably at temperatures up to 200°C.

DESCRIPTION: Future Army vehicles require compact electrical power systems with reduced cooling requirements. To accomplish this, power converter components must be compact, efficient, and capable of high temperature and high frequency operation. The use of silicon carbide (SiC) power modules fully enables this performance, but there are no commercially-available gate drive modules with the required high temperature rating to operate them. In addition, high frequency, high current rating, and high dV/dt, are needed to match the high performance of silicon carbide power electronics and meet Army power requirements. This SBIR seeks an innovative solution to provide these high temperature gate drivers. Recent developments in SiC power electronics (1) show that SiC-based gate drivers can provide the needed performance. Applications for these gate drivers include high power motor drive inverters for fans, pumps. and traction motors; and dc-dc converters for on board power, off-vehicle power, and battery pack power conditioning. The power levels of these converters range from 10kW to 500kW, depending on the vehicle and application. Gate drive modules must include industry-standard protection features, and integrated power supplies having the high-voltage isolation required for high-side drive use.

PHASE I: The contractor shall develop compact silicon carbide (SiC) gate driver designs capable of operating at temperatures ranging from -40°C to 200°C. The contractor shall develop three separate gate driver designs, optimized for a specific device type: 1) SiC MOSFETs (metal-oxide semiconductor field effect transistors), 2) depletion-mode JFETs (Junction field effect transistor), and 3) enhancement-mode JFETs. The gate drivers must sink/source current from 10A to 15A peak while operating at a frequency of 150 kHz (threshold)/ 200 kHz (objective). The gate driver shall provide >3000VRMS isolation between the logic-level control signal and the high-side gate driver output. The gate driver shall provide > 35,000 volts/microsecond common mode noise immunity. Integrated protection features shall include over-current, over- voltage, and over-temperature protection. Efficiency, reliability and service life must be maintained. Gate drivers must be suitable for use in a combat vehicle and must be able to operate at low temperatures to -40 degrees C without loss of reliability. Gate drivers must meet the above mentioned specifications for current, frequency, isolation, and common mode noise immunity over the full operating temperature range from -40°C to 200°C.

PHASE II: The contractor shall fully develop the Phase I design to produce a dual-channel gate drive module prototype capable of driving a single phase leg consisting of a pair of SiC transistors and SiC diodes. The SiC transistor type will be chosen from among the following types: MOSFETs, enhancement-mode JFETs, depletion-mode JFETs. The switch type will be chosen based on the results of Phase I effort. The phase-leg gate drive module prototype developed in Phase II will be based on the Phase I design and will meet all the requirements of the Phase I design. The contractor shall develop a gate driver test procedure using commercially available test equipment, or fabricate high-power test equipment as required. Phase II deliverables will be seven (7) single-phase leg dual-channel SiC gate drive modules developed to TRL 4.

PHASE III: Potential Phase III military applications include integration of three two-channel gate drivers developed in Phase II into a single, compact module with the ability to drive three-phase SiC motor inverters or SiC DC-DC converters. This module will simplify component packaging while increasing efficiency and reducing the size of required cooling systems. Military vehicles utilizing hybrid electric drive or power electronics associated with integrated starter generators will benefit from this technology. Potential commercial applications of this technology include insertion into the power electronics of light-, medium-, and heavy-duty hybrid electric and electric vehicles.

REFERENCES:
1. J. Richmond, S. Leslie, B. Hull, M. Das, A. Agarwal, J. Palmour, “Roadmap for Megawatt Class Power Switch Modules Utilizing Large Area Silicon Carbide MOSFETs and JBS Diodes,” Powerex Application Notes, pwrx.com, 20 Sept 2009.

2. Robin Kelley, Michael S. Mazzola, "SiC JFET Gate Driver Design for Use in DC/DC Converters," SemiSouth Application Notes, semisouth.com.

KEYWORDS: Silicon carbide, SiC, power electronics, power converter, gate driver, SiC gate drive, high temperature gate drive

A10-133 TITLE: Power regenerative suspension systems

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Improvement of ride quality over passive suspensions, combined with regeneration and redistribution of sprung mass kinetic energy that would otherwise be converted to heat and wasted.

DESCRIPTION: Current suspension designs, whether passive or semiactive, control sprung mass kinetic energy by converting excessive motion energy into heat and dissipating it. This creates temperature problems, especially in hot climates and also wastes energy that could be recovered. Present semi-active suspension systems offer ride improvement over passive suspensions, but are otherwise simply a more sophisticated means of converting sprung mass motion into heat. Active suspension systems require net energy input, which tends to increase vehicle energy consumption. The goal of this effort is to achieve ride improvement over passive suspensions while at the same time, economizing on vehicle energy consumption through intelligent management and regeneration of sprung mass kinetic energy. A power regenerative suspension system would regenerate power that would otherwise be wasted, offer the same functionality as current semiactive suspension systems, and if necessary could offer active suspension functionality.

PHASE I: The Phase I goal will be to study the feasibility and benefit versus cost of energy regenerating suspension systems, and determine what performance might reasonably be expected in comparison with currently available passive, semiactive, and fully active suspension systems. A fundamental question to be answered is, how much suspension energy can the system recover and recycle, under various operational conditions. A Phase I study would also include evaluation of various control system concepts.

PHASE II: If this effort proceeds to Phase II, the purpose of said phase would be to produce and test prototype hardware and software, based on Phase I theoretical studies, using laboratory test procedures and also on a suitable vehicle test bed. Goals include measurement of power regenerative suspension system performance, in comparison to the same platform with passive, semi-active (i.e., those using magnetorheological or electrorheological fluids) or fully active suspension systems. The prototype hardware shall be tested in both semi- and fully active modes. Performance parameters to be verified include extent of energy regeneration and ride quality under various conditions, i.e. vehicle speed and terrain roughness.

PHASE III: The anticipated end state of the proposed SBIR effort on this topic, includes not only effective power regenerating suspension actuators but also, control system hardware and methodology (algorithms) for systems capable of energy flow in either direction, i.e. from the vehicle's electrical (or perhaps hydraulic) system to actuators, or vice-versa. The latter, would enable energy-economical operation of the suspension system in the power-regenerating semi-active mode. But it will also operate in active mode if desired.

Commercial applications for power regenerative suspension systems include buses (in particular those for urban transit), whose suspension systems must function over a wide load range. Another commercial application is in off-road vehicles, which are expected to operate on terrain characterized by a high degree of roughness. Energy-regenerating suspension systems would not only regenerate sprung mass kinetic energy into a vehicle's electrical system, but also reduce propulsion energy requirements by limiting the extent of sprung mass up-and-down movement to begin with.

A significant military market exists for power regenerative suspension systems, both in newly-designed wheeled vehicles and also, for retrofit of said suspension systems into existing vehicles or vehicle designs. Examples of existing wheeled vehicle designs to which power regenerative suspension systems could be retrofitted, include the High Mobility Multipurpose Wheeled Vehicle and Family of Medium Tactical Trucks.

Another military market is tracklaying vehicles, whereby power regenerative suspension actuators would be substituted for conventional dampers (shock absorbers) in new vehicle designs, or retrofitted to existing designs. With the large world-wide fleet of existing tracklaying vehicle designs of various sizes, a substantial market possibility exists for technology developed in this SBIR effort.

REFERENCES:

1. http://adt.lib.swin.edu.au/uploads/approved/adt-VSWT20060307.120939/public/02chapter1.pdf
(Thesis on energy regeneration, including suspensions)

2. http://www.swri.org/9what/releases/1997/rd.htm
(Southwest Research Institute regenerative hydraulic suspension system)

3. http://www.sae.org/technical/papers/910659

4. http://www.sae.org/technical/papers/950775, (SAE papers)

5. http://www.fisita2008.com/programme/programme/pdf/F2008-03-066.pdf
Paper written in China, Permanent-magnet DC motor actuators application in automotive energy-regenerative active suspensions.

6. http://www-robotics.jpl.nasa.gov/publications/Charles_Bergh/THORNHILL_03_spie5083.pdf
Describes an off-road vehicle with integrated electric propulsion and electromechanical active suspension featuring " .... energy conserving features such as regenerative damping control ..". System was designed by University of Texas Center for Electromechanics.

KEYWORDS: Suspension, semi-active suspension, active suspension, energy, power, regeneration, ride, ride absorbed power, vertical acceleration, EMASS (Electromagnetic Active Suspension System)

A10-134 TITLE: JP-8 Hydraulic Power System for Legged Robot

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: 30-45kW power system consisting of high power density diesel and/or JP-8 engine, fuel consumption less than 0.66lb/kW*hr and weigh less than 110 lbs. for the purpose of powering a hydraulic pump at 6000 rpm for legged robot mobility.

DESCRIPTION: Military robots have great advantages and are needed for a vast array of tasks in environments around the world. The rough mountainous terrain found in Afghanistan and other areas in the world demand alternatives to tracked and wheeled robotic mobility. Legged robots are able to navigate rocky, off-road conditions including steps, boulders, etc. This kind of mobility has much better performance when utilizing a hydraulic-driven system. This is due to high torque transients and the irregularity of motion. TARDEC Intelligent Ground Systems has built a gasoline powered, hydraulic driven legged robot named the Big Dog and has had huge success in its demonstration. TARDEC is building a larger, more capable robot named the Gen. II Big Dog and is in need of a diesel and/or JP-8 fueled power system for it. The robotic system has limits on fuel consumption and weight. The power system would be designed to directly drive a hydraulic pump. This would have an alternative use as a non-primary power source for larger military vehicles that require a hydraulic power unit for hydraulic loads such as turret drives. Currently, most/all Auxiliary Power Units (APUs) and Gensets provide only electrical power. Also, the Army fields thousands of smaller construction vehicles, which utilize hydraulic power to move, lift, pull, push, and turn attachments. These vehicles could also use this high power-density technology. Hydraulic systems are on many commercial vehicles, both where this size of a power system could be considered non-primary or primary - forklifts, Bobcats, cement trucks, construction lifters, etc.

PHASE I: Design a power unit that meets the objectives of the above description, and using modeling and simulation, validate the design.

PHASE II: Develop the power unit designed in Phase I. Validate the design and the modeling and simulation through testing. Measure system hydraulic pressure as a result of transient load changes such as piston movements. Demonstrate the drive on a military legged robot.

PHASE III: Hydraulic systems are on many commercial vehicles, both where this size of a power system could be considered non-primary or primary - forklifts, Bobcats, cement trucks, construction lifters, etc.

REFERENCES:
1. http://www.bostondynamics.com/robot_bigdog.html

2. Springer Handbook of Robotics. Siciliano, Bruno & Khatib, Oussama. IEEE, 2008.

KEYWORDS: engine, hydraulic, power, jp-8, diesel, robot, light, non-primary

A10-135 TITLE: <u>High Mobility Robotic Platform with Active Articulated Suspension</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The Army has a critical need for a high mobility platform capable of safely transporting heavy, fragile or explosive, materials over rugged mountainous terrains.

DESCRIPTION: The mobility platform, having a gross vehicle weight under 4,000 pounds, must be configured to maintain payloads of up to 1000 pounds in a level position during transport over rough terrain. The platform must also be able to isolate the payloads from the shock and vibration effects resulting from mobility operations over rough terrain. The platform must be capable of off-road mobility as defined by the ability to ascend/descend and move laterally across 30 degree slopes and to navigate over obstacles of at least 18 inches in height. The mobility platform must be able to navigate over a one meter gap. The mobility platform must be capable of moving at speeds of dismounted soldiers over all types of terrains (mountainous areas, paved/unpaved roads, mud, sand, concrete debris). The mobility platform’s payload mounting area must be reconfigurable to accommodate safe transport of multiple payload types, such as wounded soldier transport or resupply items like ammunition, batteries, and tires. The mobility platform system configuration shall include on-board sensors, electronics and processors to provide teleoperation through an operator control unit (OCU). The platform system shall sense terrain mobility induced disturbances and isolate the payloads from shocks and vibrations, while maintaining the payload in a level position.

A key feature of such mobility platforms would be articulated suspension mechanisms that are dynamically controlled depending on the operational environment. This would allow for active control of payload position and to reduce the effects of rough terrain. The platform must be capable of navigating an 8 inch step at a speed of at least 8 mph while limiting the shock transmitted to the on-board electronics and payloads to a maximum of 3 g's.

In order for such a vehicle to be operated quickly and efficiently over rugged mountainous terrain, the platform should automatically sense and respond to terrain induced shocks & vibrations to maintain dynamic stability.

Proposals are sought which address the following technology needs:
• Platform designs featuring articulated, controlled suspensions allowing sufficient flexibility for traversal of challenging terrain. The desired mobility platforms would be large enough to support meaningful carrying capacities of 1000 pounds; but, have a gross vehicle weight under 4,000 pounds.
• Whole-body maneuver and balance control systems that are capable of maintaining platform and payload stability in the presence of significant disturbances, particularly, terrain induced disturbances.

PHASE I: Develop a proof-of-concept active articulated suspension prototype. As part of the development, a full teleoperated mobility platform design, models for key components, and simulation software shall be delivered to validate the overall design. The platform design should possess the following for relevancy: The mobility platform design shall feature an active articulated suspension that would allow traversal of challenging mountainous terrain. The mobility platform selected for integration of the active articulated suspension shall have a drive-by-wire design and have a Joint Architecture for Unmanned Systems (JAUS) compliant low-level controller. The platform shall have a gross vehicle weight under 4,000 pounds and be able to transport and maintain payloads of up to 1000 pounds in a level position during mobility operations over rough terrain and while scaling obstacles up to 18 inches in height. The active articulated suspension system should have sensors, electronics and controls to sense instantaneous terrain induced disturbances and adjust the suspension system operational characteristics to minimize payload disturbances. The mobility platform, to mitigate the effects of terrain induced disturbances, should possess whole-body maneuver & balance control systems capable of isolating the onboard electronics and payloads from shocks and vibrations, while maintaining the payload in a level position.

PHASE II: Using the Phase I design requirements and technical documentation, the contractor shall fully develop, fabricate and deliver a prototype of the teleoperated mobility platform with active articulated suspension. The phase II effort shall develop a highly maneuverable mobility platform with adaptable on-the-fly active articulated suspension system to support operations in mountainous terrains. The mobility platform shall have whole-body maneuver and balance control systems that are capable of maintaining platform and payload stability sufficient to mitigate on-board terrain induced disturbances. The mobility platform selected for integration of the active articulated suspension shall have a drive-by-wire design and have a Joint Architecture for Unmanned Systems (JAUS) compliant low-level controller. The platform OCU and low-level controller's interface control and control signals shall be open source, accessible through government in-house developed software coding and JAUS compliant. The platform shall have a gross vehicle weight under 4,000 pounds and be able to transport and maintain payloads of up to 1000 pounds in a level position during mobility operations over rough terrain and while scaling obstacles up to 18 inches in height. The platform must be capable of off-road mobility as defined by the ability to ascend/descend and move laterally across 30 degree slopes. The mobility platform must be able to navigate over a one meter gap. The payload mounting area must be reconfigurable to accommodate safe transport of multiple payload types, such as wounded soldier transport or resupply items like ammunition, batteries, and tires. The active articulated suspension system should have sensors, electronics and controls to sense instantaneous terrain induced disturbances and adjust the suspension system operational characteristics to minimize disturbances to onboard electronics and payload. The mobility platform, to mitigate the effects of terrain induced disturbances, should possess whole-body maneuver & balance control systems capable of isolating the onboard electronics and payloads from shocks and vibrations, while maintaining the payload in a level position. Teleoperation is required to safely assess the platform performance characteristics. Additionally for safety reasons, the teleoperation capability shall be backed up with a second-communication-system-based emergency stop. Once constructed, the contractor shall provide manpower and materials support to a performance validation test that will be conducted to test the developed teleoperated mobility platform against the requirements in a relevant military operational environment.

PHASE III: The mobility platform sought here would find significant use in commercial markets where there is a need to assist humans with movement of heavy objects in unstructured environments. Such markets include construction, delivery, warehousing, agriculture, and mining. The first responder community could utilize this platform for urban search and rescue missions, which might require personnel extraction or operations in hazardous areas. Construction equipment manufacturers may also be interested, specifically in mining type applications where rugged terrains must be traversed to extract heavy material. The off-road ATV community is another candidate that may seek to benefit from the development of this technology.

REFERENCES:
1. Iagnemma K. and Rzepniewski, A. and Dubowsky, S. and Schenker, P."Control of robotic vehicles with actively articulated suspensions in rough terrain"Autonomous Robots. Vol 1 2003 4: 5-16.

2. "Control Improvements for Low Impedance Bipedal Walking Robots" Pratt, G. A., Hofmann, A. G., Willisson, P., Bolton, C., American Controls Conference, Boston, MA, June 2004

3. Iagnemma, K. and Dubowsky, S. Mobile Robots in Rough Terrain. Springer, 2004.

KEYWORDS: Active articulated suspension, active suspension, inherent stable mobility, articulation, tracks, wheels, unmanned ground vehicle, rugged terrain mobility

A10-136 TITLE: Scalable technology for military and humanitarian water purification applications

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop and demonstrate a low cost, energy efficient water treatment system that can be used by organizations involved in humanitarian assistance, disaster relief and expeditionary operations.

DESCRIPTION: The current and future demands for fresh water and water reuse, sustainable desalination of seawater, groundwater and wastewater, and the need to remove toxins and other harmful agents in water will continue and rise. Current military systems are very effective in treating any source water to produce water meeting military drinking water standards. However, the size, weight, energy requirements, maintenance (cleaning), and complexity of these systems limit their utility for distributed operations for small units and small operating bases. In this context, new technology is needed with the capacity to remove salts as well as toxins and other harmful agents efficiently.

Technology is required that utilizes low energy consumption, equal to or less than 20 watt-hr/gallon, and avoids the production of harmful chemical discharge while also reducing current maintenance associated with the cleaning and replacement of filters and membranes.

The water treatment system must be able to treat any source water including seawater (to 45,000 ppm TDS), brackish, turbid, and NBC-contaminated sources. The unit should be lightweight weighing less than 500 pounds and should ship with less than or equal to 25 cubic ft of volume. The production capacity should be 300 gallons per day on seawater. The unit should have higher productivity or efficiency for fresh water compared to seawater. The unit should require minimal technical expertise to operate. The product water should meet the EPA National Primary Drinking Water Regulations drinking water standards.

PHASE I: A proof of concept breadboard unit should be constructed that desalinates seawater (45,000 ppm TDS) to less than 500 ppm TDS and in fresh water mode treats source water to 15-minute silt density index values (ASTM D4189-07) of less than 3.0 and turbidity values less than 1.0 NTU while showing a pathway to meet the weight, volume, and energy metrics. Complete a conceptual design for developing and prototyping a material system that is suitable for use by US Army, US Marine Corps and US Navy units across the range of operations.

PHASE II: Based on best design parameters discovered in Phase I build and demonstrate a prototype which can be used by various military and other defense and support organizations for military, humanitarian assistance, and disaster relief operations. The prototype will desalinate seawater (45,000 ppm TDS) to less than 500 ppm TDS and in fresh water mode treat source water to 15-minute silt density index values (ASTM D4189-07) of less than 3.0 and turbidity values less than 1.0 NTU while meeting the weight, volume, and energy metrics. A final prototype demonstration will be required 12 months from the initial demonstration that incorporates updated user requirements and design changes.

PHASE III: Commercialization ¨C Build scaled system to meet the needs for small unit use at an expeditionary Army water treatment site. Create a manufacturing plan that will facilitate both product scaling and low rate initial production.

REFERENCES:
1. http://www.epa.gov/safewater/contaminants/index.html

2. http://www.foresight.org/challenges/water001.html

3. http://www.h2ro.com/_Solutio2.htm

4. http://www.alternet.org/module/printversion/120395

KEYWORDS: Chem-Bio Decontamination, Water treatment, Reverse Osmosis (RO) alternative

A10-137 TITLE: Real Time Thermal Mapping Techniques for Elastomeric Track Components

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The desired product would result in an instrument and recording package that can be mounted on an Abrams test vehicle with novel sensors charting real-time operating temperatures of track components. The novelty will be in developing sensor technology that will not affect the performance or durability of the track components and provide critical boundary operating conditions necessary for the design and development of the next generation, high durability track components.

DESCRIPTION: Understanding the actual operating temperatures of track components over various test terrains such as Aberdeen or YPG is critical for specifying the durability requirements of future track components. Historically operating conditions for track components were specified for a robust operating range and accommodated “Cold War" environmental conditions. Recent operating conditions in Southwest Asia have significantly challenged the durability of track components and, given the very high ambient temperatures in this region, Heavy Brigade Combat Vehicles have experienced operating temperatures in the 120-140 F and these conditions on asphalt surfaces have driven the operating temperatures of the track components above 250 F. The traditional elastomeric materials for track components were developed around Natural Rubbers (NR) and Styrene Butadiene Rubbers (SBR). These materials have operating limits around 225-240F, consequently new higher temperature elastomeric materials are required. Accurate operating specifications are required and monitoring the temperatures of track components real-time and over various course terrains is Specifications and need to be specified. Track durability of Abrams and Bradley track systems decreased by 60-70% in support of operations in Southwest Asia in 2004, therefore, new requirements need to be developed and specified to meet these new challenging environments. Track consumables costs are the # 1 highest cost driver for HBCT and new targets for the Abrams M1E3 modernization activities target a 5000-mile track. The elastomeric track components, namely track bushing and road wheel backer pads are the durability limiters today, therefore accurate real-time measurements of track components is a necessary pre-requisite for establishing requirements for improved track components.

Light weight sensors that can be molded into rubber track components have proven to create a location for the onset of fatigue failures (i.e. crack initiation, crack propagation). Consequently, fundament R&D activities will necessary to develop a real-time measuring sensor that can survive without pre-maturely destroying the durability of the instrumented component. Track components that degrade over time will increase in modulus and stiffness, hence accelerating the thermal activity of the component as it continues to operate. Its imperative that the thermal sensors developed maintain their precision and accuracy throughout the life of the test to capture the thermal profile of the degraded rubber components and assist in linking thermal history, component degradation and impacts of this degradation on the key operational requirements such as hull vibration. Stopping the vehicle and taking real-time thermal measurements with surface probe thermocouples is satisfactory, however components rapidly decrease in temperature due to the convection of the track body and this technique limits the precision and accuracy required to capture real operational thermal data of the respective components.

There are no commercially available sensors or temperature measuring devices that have been developed for this purpose. Developing a novel sensor or sensing technology suite for track components will accelerate the requirements, specifications and development of higher temperature track components that extend the life of our current track systems. These developments will significantly lower the life cycle cost of our track systems and reduce and logistics burdens for HBCT. This instrument package will be directly applicable to other tracked vehicles. Analysis of operating temperatures of solid rubber components in other military applications, aerospace, automotive, energy and industrial markets will assist in expanding the market potential of this technology set.

PHASE I: Phase I would consist of developing a solid science and engineering proposal based on unique sensors or sensing techniques that would provide accurate real-time data. These sensors or sensing technology would need to measure accurately the real-time temperature of track components. The highest priority and proof of principle threshold test would focus on the ability to measure track bushing temperatures during operation. Given these bushings are located in a constrained environment and limited exposure to the bushing surface, the ability to measure thermal temperatures during operation would be the technical and engineering challenge. The sensors or sensing technology cannot affect the performance or durability of the track bushings; therefore operate in a non-destructive manner with respect to the performance of the track bushing. The bushings, track system would be tested under TRADOC test conditions utilizing an n Abrams T-158LL track. These conditions would consist of a paved course, off road and off-road rocky courses. Consequently, these sensors or sensing technology would need to be robust enough to operate in these harsh environments and be capable of surviving the various road surfaces and speeds of these track systems. The top speed theses sensors suites would need to be designed for is 40 mph. The data logging equipment would need to be robustly designed and mounted on the interior or exterior of the vehicle to ensure data collection is accurate and precise. Mastering the real-time temperature measurement and logging profile of track bushings would be the first hurdle, and then this technology would be adapted to the road wheels, road wheel backer pads and the ground pads.

PHASE II: This effort would take the Phase I proposal and proceed to design and demonstrate, in the laboratory the sensing, data logging and data capture technology. Once passed this milestone, the sensing technology for track bushings would be developed, tested and demonstrated on a T-158LL track system at YPG or Aberdeen at low speeds and on a paved track. The accuracy and precision of this system would be validated at the higher speeds on the remaining test surfaces and, based on successful validation; the equipment would be tested under the full TRADOC tests conditions. Once the real-time temperature monitoring test equipment was validated with track bushings, this technology would be adapted to “proof of concept" with road wheels, road wheel backer pads and ground pads. At each component test, sufficient data would be gathered to validate the accuracy, precision and reliability of the test equipment. This data would then be utilized to develop a thermal model for the track system providing valuable development and engineering data for modeling and simulation activities.

PHASE III: Phase III activities would include the Low Rate Initial Production (LRIP) of complete packaged senor/sensing technology data loggers and data analysis. Other markets that would find this test suite valuable would be energy exploration, aerospace, off-road equipment and manufacturing. Elastomeric components fail routinely in sectors and new unique R&D tools to facilitate improved understanding of requirements would accelerate the development of higher durability components and life.

KEYWORDS: Thermal sensors for solid rubber components, non-destructive thermal sensors for rubber components, robust thermal sensors for real-time dynamic measurements, robust thermal sensors, non-destructive for elastomeric components

REFERENCES:
1. Schematics for components to be tested. (Uploaded 4/26/10)

A10-138 TITLE: <u>Development of Super-Capacitor with Improved Energy Density</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Development of High Energy Density Supercapacitor With Non-flammable Electrolyte

DESCRIPTION: Supercapacitor are known for their capability to provide high power. The most common supercapacitors, also known as “ultra” capacitors, use forms of carbon or non carbon battery electrodes as active materials. These capacitors exhibit many performance characteristics that make them attractive for use in military applications such as in tactical vehicles or EM armor and weapons. Supercapacitors can deliver high power discharge pulses, have very good cycle life, and operate well at low temperatures. However, they have the disadvantage of having relatively low specific energy density (Wh/kg) or energy density (Wh/l). Therefore, the Army is requesting proposals to develop supercapacitor systems that will store more than 20Wh/kg at the cell level while retaining the advantages of high power capability, good cycle life, fast response time (100us or faster), and good high termperature (80C) and low temperature (-50C) performance. Further, due to the extreme operational environments of the military, supercapacitors which utilize a non-flammable electrolyte are desired.

The goal of this technology development is to design, develop, and test an advanced supercapacitor, which is capable of providing specific energy density meeting or exceeding 20Wh/kg. While the primary objective of the topic is to increase the specific energy density of supercapacitors, in addition the supercapacitors developed must show, at a minium, a specific power density of 1 kW/kg and a cycle life of 500 thousand cycles. Exceeding any of these threasholds is advantageous.

PHASE I: Conduct research to demonstrate the feasibility of the proposed concept through materials analysis and testing. Phase I must include a demonstration of the materials' specific energy density performance in laboratory cells. A research study in the form of a report is expected as a phase I deliverable.

PHASE II: Further modification and demonstration of the proof of the concept, with the fabrication and testing of multiple supercapacitor cells, is required in phase II. Cells produced should demonstrate the desired performance while retaining the advantages of high power capability, good cycle life, and good low temperature performance. Other desirable characteristics include limited self discharge, good charge/discharge efficiency, long calendar life, and low cost. Delivery shall include five (5) demonstrator supercapacitors cells with capacites of no less than 1Wh each for lab verification and evaluation.

PHASE III: Technology developed in this topic could be scale up for the process of making high energy density supercapacitors for military and/or commercial applications. The results of the development of the high energy density supercapacitors should enable their incorporation into new types of military systems and commercial hybrid vehicles. The goal in this phase will be to initiate the manufacturing processes to produce high energy density supercapacitors and to evaluate the products for military and commercial applications.

REFERENCES:
1. Conway, B.E., Electrochemical Supercapacitors, Kluwer Academic / Plenum Publishers, New York (1999).

2. Portet, C., Yushin, G. & Gogotsi, Y. Carbide Derived Carbons for Electrical Double Layer Capacitors: Electrochemical Performances of Carbon Nanoparticles and Influence of Carbon Particle Size J. Electrochem. Soc 155 (7) (2008).

3. K. Naoi, "Limits to Cell Operating Voltages of Electrochemical Capacitors", The 5th International Symposium on Large EC Capacitor Technology and Application, Long Beach, California, June 9-10, 2009.

4. C. Arbizzani, M. Biso, D. Cericola, M. Lazzari, F. Soavi, M. Mastragostino, "Safe, high-energy supercapacitors based on solvent-free ionic liquid electrolytes", J. Power Sources, 185(2008)1575.

KEYWORDS: supercapacitor, energy density, non-flamble.

A10-139 TITLE: <u>Lithium Air Rechargeable Battery</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a low cost Lithium Air rechargeable energy battery for Non primary Power Systems and silent watch applications that can provide a much higher energy density than either Lithium Ion or current Lead Acid batteries.

DESCRIPTION: Lithium Ion batteries have high energy densities as compared to many other battery systems. With the growing requirement for high energy and long duration energy storage system for Silent Watch, the Army has interest in supporting higher energy density storage system research to meet this need and support tomorrow's warfighters. The Li Ion positive electrode represents a major obstacle to progress. An alternative approach involves replacing the interaction electrode with a porous electrode and allowing lithium to react directly with oxygen from the air. This battery is called Lithium Air battery. Current rechargeable Lithium Air batteries have limited life. The Army is soliciting proposals to develop Lithium Air batteries that will deliver more than 1000 Wh/kg (C/20 rate desired) at the cell level while having more than 200 full charge/discharge cycles in open air with oxygen from the air or other sources. Other desirable characteristics include limited self discharge, good charge/discharge efficiency, and good low temperature performance, high charge/discharge current densities, long calendar life, and low cost. Proposals must provide a clear discussion, based upon available data and theory, to support an assertion that the design to be developed will offer acceptable performance and meet the energy storage goal. Approaches of interest must include a demonstration of the cell performance in open air cells by the end of Phase 1.

The goal of this technology development is to design, develop, and test an advanced rechargeable lithium-air battery.

PHASE I: Conduct research to demonstrate feasibility of the proposed concept through cell design and testing. Phase I will address the 1000 Wh/kg specific energy performance characteristics and demonstrate progress towards the C/20 rate and 200 cyles goal by building and testing experimental cells. A technical report documenting findings is expected from phase I deliverables.

PHASE II: Modify the design and further demonstrate proof of the concept with the fabrication and testing of multiple lithium-air cells (>3 Ah). The cycle life of the test cells shall be more than 200 full cycles while the Lithium Air battery should demonstrate specific energy density of more than 1000Wh/kg (C/20 rate desireable). Delivery shall include prototype cells and small multicell demonstrator batteries for lab verification and evaluation.

PHASE III: The resulting technology will be used to produce batteries suitable to be intregrated into current Army ground vehicle platforms for Silent Watch. It will also enable increased performance of commercial electric vehicles. Markets for the technology include Military Vehicle Original Equipment Manufacturers (OEMs), battery manufacturers, and commercial electric vehicle OEMs, and computer OEMs. The goal in this phase will be to initiate the manufacturing processes to produce Lithium Air batteries and to evaluate the products for military and commercial applications.

REFERENCES:
1. K. M. Abraham and Z. Jiang, “A Polymer Electrolyte-Based Rechargeable Lithium/Oxygen Battery”, J. Electrochem. Soc., 143(1996)1.

2. J. Read, “Characterization of the Lithium/Oxygen Organic Electrolyte Battery”, J. Electrochem. Soc. 149(2002)A1190.

3. Linden, D.; Reddy, T.B., Eds.; Handbook of Batteries, 3rd ed.; McGraw-Hill: New York, 2002.

4. Aurelie Debart, Jianli Bao, Graham Armstrong, and Peter G. Bruce, “Effect of Catalyst on the Performance of Rechargeable Lithium/Air Batteries”, ECS Trans. 3 (27), 225 (2007)

KEYWORDS: lithium air, batteries, electrolyte, separators, specific energy, long life

A10-140 TITLE: <u>Rapidly Deployable Thin Film Camouflage</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Exploit current commercial vinyl adhesive wrap industry to design and manufacture an adhesive camouflage appliqué product to be used over existing military vehicle paint schemes in lieu of repainting.

DESCRIPTION: Military vehicles are typically painted in one of a variety of paint schemes to match the terrain of the area of operation. Preceding Desert Storm hundreds of military vehicles had to be converted from the Woodland paint scheme to Desert Tan. This was a major effort, took time and posed risks to the environment and personnel carrying out this mission due to the toxic nature of the Chemical Agent Resistant Coating (CARC) paint used. At the end of this conflict another coat of CARC paint was required on many of these vehicles to return them to the Woodland or Olive Drab color schemes.

There currently exists a vinyl wrap market that provides wraps for commercial and private use. Images and/or patterns are printed directly on the substrate and are applied to the vehicle surface with a pressure sensitive adhesive. By leveraging existing technology, investigating shortfalls in durability and addressing these shortfalls it may be possible to create a camouflage product with an infinite variety of colors and patterns that could be quickly applied directly to the surface of existing military vehicles in lieu of repainting with CARC. The colors and patterns would be custom made for the area of vehicle operation. The advantages are a reduction in time, costs and risks to personnel and the environment when changing color and camouflage schemes on military vehicles as compared to repainting with CARC paint.

PHASE I: Demonstrate feasability by applying current state of the art vinyl wrap product to a CARC paint coated surfaces with and without non skid texture. Using CARC paint spec MIL-DTL-53039C (and associated documents) and MIL-STD-810G as a reference, identify requirement shortfalls for current state of the art vinyl wrap (appliqué) substrate, inks, topcoats, adhesives and manufacturing technology as compared to CARC paint. Documents all results, evaluate shortfalls and deliver recommendations in report to be delivered to the Army.

PHASE II: Address shortfalls discovered in Phase I. Develop printable vinyl appliqué that meets Army color, spectral reflectance, gloss and mature the physical (abrasion, impact, tear, adhesion, etc) and environmental (temperature, humidity, salt fog, submersion, fuels, etc) durability of the appliqué system (substrate, inks, adhesives and top coats). Camouflage scheme to be defined by the Government. Deliver enough applique product to cover 3 vehicle systems, approximately 3000 square feet, for goverment sponsored performance testing and user evaluations.

PHASE III: A manufacturable and fieldable adhesive camouflage appliqué product, supplied as a kit, that is applied over current CARC paint schemes, is removable and is compatible with Army requirements, supply and logistics. Potential dual use applications include applying a camouflage applique to shipping containers, support equipment, shelters, etc.

REFERENCES:
1. MIL-DTL-53039C DETAIL SPECIFICATION - COATING, ALIPHATIC POLYURETHANE, SINGLE COMPONENT, CHEMICAL AGENT RESISTANT

2. MIL-STD-810G ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS

3. http://techcon.ncms.org/CTMA_Tobyhanna2007/pdf/Tues%201545%20Tim%20O'Neill.pdf

4. http://www.averydennison.com/avy/en_us/About-Us/Our-Brands/Avery-Graphics

KEYWORDS: Chemical Agent Resistant Coating, CARC, appliqué, paint, color, camouflage, wrap, vinyl

A10-141 TITLE: Acoustic Signature Self Monitoring System

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop sensors and software to measure noise emissions from military vehicles during specific conditions and provide crew with feedback regarding likelihood of being detected, identified, and located. Demonstrate system on Army Vehicle.

DESCRIPTION: This technology will address the gaps identified in TRADOC PAM 525-66 7 MAR 08 FOC 03-02 for Air/Ground platform signature reduction. This technology will monitor aspects of vehicle health such as engine prognostics and diagnostics. Based on the environment, a range-based software will be able to calculate how far away a vehicle can be detected. This project will be software focused on the following: sensor monitoring and onboard vehicle prediction acoustic signature. We will use limited sensors to collect critical data points for onbard vehicle measurement. The system of sensors and software that will be developed can be used to measure the noise emissions from military vehicles during Tactical Idle/Silent Watch. These sensors will be commercially available. The acoustic effectiveness of Army vehicles during Tactical Idle/Silent Watch operations varies depending on the environment in which the vehicle operates. This system would measure vehicle noise emissions using onboard sensors, and predict the sound pressure levels at a specific distance. These vehicle noise emissions would then be evaluated according to the environment in which the vehicle operates and provide the operators feedback as to the likelihood of being detected. The technology will demonstrate the effectiveness of the system on an Army Vehicle. In additon, it will support multiple armor configurations.
The current status of technology/product is TRL 2.

PHASE I: Phase I of this effort will be a study to determine the feasibility of predictiing the acoustic signature from onboard sensors. Once the acoustic signature is predicted, it will then be determined if it is feasible to use that data to determine detectibility range for other different environments.

PHASE II: For Phase II of this effort, the technology will be integrated onto a vehicle. The Army would be providing the contractor with the appropriate data. The contractor will design the brass board system and the Army will make the vehicle available for demonstration. The deliverable for this project will be the architecture and the two software pieces as well as a written report.

PHASE III: For Phase III, we will locate a PEO partner to support this idea and develop the system for their vehicle. A military application would be Ground Combat Vehicles (GCV). This application best fits timeline wise for this project. Transitions include the following: GDLS, BAE, Boeing, Lockheed Martin, AM General, Oshkosh. A commercial application would be to predict noise emission for loud manufactuing machinery. The system would provide a warning signal if any change is required in hearing protection in that area whether it be indoors or outdoors.

REFERENCES:
1. http://www.dtic.mil/ndia/11ground/evans.pdf

2. http://www.combatindex.com/mil_docs/pdf/std/1400/MIL-STD-1474D.pdf

3. MIL-STD-1474D

KEYWORDS: onboard, acoustic, signature, prediction, detection, range, diagnostic, prognostic

A10-142 TITLE: <u>Hands-Free and Heads-Up Control of Unmanned Ground Vehicles</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective is to develop a system for controlling an unmanned ground vehicle without requiring the use of the operator's hands, while allowing the operator to maintain situational awareness of his surroundings and that of the robot.

DESCRIPTION: Tele-operation is currently the most reliable method for operating an unmanned ground vehicle (UGV). However, there are a number of disadvantages to standard methods of tele-operation, such as losing situational awareness while immersed in the display and requiring the operator to give up his weapon in exchange for a control device. This topic seeks alternative heads-up and hands-free methods for controlling robotic vehicles. The operator will likely be on foot and it is therefore necessary that the system be rugged, lightweight, and operate effectively in noisy environments and while the operator is engaging in various physical activities. Besides driving the UGV, the hands-free system can also be used for controlling cameras and lights, selecting vehicle or manipulator poses, or controlling a manipulator. The system must not substantially obstruct the vision of the operator, while still allowing sufficient situational awareness of the robot's environment. The system needs to operate reliably at distances up to 100 meters, in non-line-of-sight conditions, and with latency less than 100 ms.

We will consider a variety of hands-free methods including, but not limited to, brain-computer-interface (BCI), eye tracking, sub-vocalization, and speech. Based on past experience with speech control for unmanned systems, we recognize that a usable hands-free system needs to provide high correct classification rates (> 95%) and low false rejection rates (< 5%). Due to the likely low fidelity of the hands-free modality, compared to a joystick, it is expected that some measure of semi-autonomy will be needed. For example, the ability to command the vehicle to drive to a particular object or location will be useful. We will consider different display technologies, including, but not limited to, monocular, binocular, and wearable displays, although systems that entail occasional heads-down viewing will require a higher level of autonomy. It is expected that a significant amount of human factors research will be required for this project, since past experience with monocles suggest that operators do not like to have their vision obstructed. Approaches will be compared on the effectiveness of vehicle control, burden on the user, ruggedness and cost.

PHASE I: The first phase consists of initial system design, researching sensor options, investigating signal and video processing algorithms, and showing feasibility on sample data. Documentation of design trade-offs and projected system performance, including operator effectiveness and situational awareness, shall be required in the final report.

PHASE II: The second phase consists of a final design and full implementation of the system, including sensors and software for the robot and the operator control unit, wireless communications, and display. At the end of the contract, effective non-line-of-sight hands-free control of an unmanned ground vehicle shall be demonstrated in a realistic outdoor environment, where the operator's situational awareness will be measured. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in the project and a user's guide and technical specifications for the prototype system.

PHASE III: Military applications include all those that entail control of an unmanned system where hands-free and heads-up capabilities are desired, such as combat engineer and infantryman. Civilian applications include toy and video game interfaces and assistance for the physically disabled. Until operating systems become more open, the most likely path for commercialization for a hands-free and heads-up control system is to partner with a commercial supplier of military robots.

REFERENCES:

1. http://research.microsoft.com/en-us/um/people/desney/projects.htm (Human computer interface)

2. http://www.neurosky.com and http://www.emotiv.com (Consumer BCI systems)

3. http://www.eyegaze.com/content/instrument-specifications (Commercial eye tracking system)

4. http://www.opticsinfobase.org/abstract.cfm?URI=oe-14-10-4328 (Video-based eyetracking methods and algorithms in head-mounted displays)

5. http://research.microsoft.com/en-us/projects/robust/default.aspx (Noise robust speech recognition)

6. http://www.robot.uji.es/EURON/visualservoing/tutorial/

KEYWORDS: robotics, speech recognition, visual servoing, autonomy, brain-computer interface, heads-up display, eye tracking

A10-143 TITLE: Perception for Persistent Surveillance with Unmanned Ground Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop a system to allow an unmanned ground vehicle to extract useful information from surveillance video, to reposition itself to optimize data collection and communications, and to conceal itself.

DESCRIPTION: Persistent surveillance is a major role envisioned for Unmanned Ground Vehicles (UGV's). Persistent surveillance refers to the use of networked assets over a wide area and extended duration to collect and process sensor data to produce actionable intelligence, which includes the type, location, and movement of identifiable threats or targets, as well as generally suspicious activities. Persistent surveillance dynamically reallocates assets and does not imply complete and constant coverage and can employ a mix of different platforms and sensors providing complementary coverage and resolution. Common platforms used for persistent surveillance include unmanned aerial vehicles (UAV's) and stationary unattended ground sensors (UGS's). The focus of this topic is the use of UGV's for persistent surveillance. Unlike UAV's, UGV's can remain in place without significant energy expenditure and can maneuver inside buildings, tunnels and constrained spaces. Unlike UGS's, UGV's can reposition and reorient themselves and, with a manipulator arm, they can improve their positions for surveillance, cover and conceal their positions, and emplace and retrieve UGS's. A major disadvantage is that UGV's have to deal with the many obstacles on the ground.

Although there are many potential sensors that can be used in persistent surveillance, in this topic we are focusing on visual (and perhaps infrared) imaging sensors and acoustic sensors. Communications bandwidth is and will remain a limited resource. Even with video compression technologies, there is insufficient bandwidth to upload all video and high-resolution still images from all persistent surveillance network nodes. Artifacts due to heavy video compression would degrade most analysis applications and viewing all the data would overwhelm analysts. Local processing is therefore preferable to central processing to extract actionable intelligence from the sensor data and to plan sensor position adjustments. An individual node can determine whether or not there has been a significant change in the situation that would warrant transmitting a package of sensor-level data.

The scenario to be addressed in this topic is that a UGV has been placed at a particular location in order to perform surveillance of a particular area, whose location has been provided by maps, landmarks and/or GPS. Capabilities desired for the UGV include positioning in the correct orientation to view the desired area, finding a location that offers concealment, periodically adjusting position/orientation to improve concealment, data collection and/or communications, and extracting actionable information from the sensor stream. In the real world one or more of these functions may be performed via tele-operation, but the intent of the research is to determine how much can be performed autonomously by the UGV. Information of interest includes detection and analysis of humans and vehicles, analysis of traffic patterns, and identification of suspicious activities or behaviors. The intended platform size is on the order of 20 Kg and the platform is expected to function for 72 hours, so energy efficient algorithms are of interest. UGV platform and payload development, including sensors and communications, are outside the scope of this topic.

PHASE I: The first phase consists of scenario/capability selection, initial system design, researching sensor options, investigating signal and video processing algorithms, and showing feasibility on sample data. Documentation of design tradeoffs and projected system performance shall be required in the final report.

PHASE II: The second phase consists of a final design and full implementation of the system, including sensors and UGV software. At the end of the contract, extraction of actionable information and autonomous local maneuvering shall be demonstrated in a realistic outdoor environment. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in the project and a user's guide and technical specifications for the prototype system.

PHASE III: The end-state of this research is to further develop the prototype system and potentially transition the system to the field, in support of OEF/OIF missions and objectives. Potential military applications include monitoring highways, overpasses, intersections, buildings and security checkpoints. Potential commercial applications include monitoring high profile events, border security and commercial and residential surveillance. The most likely path for transition of the SBIR from research to operational capability is through collaboration with robotic companies from industry or through collaboration with the Robotic Systems Joint Project Office (RS JPO).

REFERENCES:
1. http://www.afcea.org/signal/articles/templates/SIGNAL_Article_Template.asp?articleid=97&zoneid=88 (Persistent Surveillance Comes Into View)

2. http://www.dtic.mil/srch/doc?collection=t3&id=ADA497188 (Automated Knowledge Generation with Persistent Surveillance Video)

3. http://www.tardec.info/roboticsrodeo/Documents/PersitentStare.pdf (Persistent Stare Scenarios)

4. http://www.ee.washington.edu/research/nsl/papers/iscas-08.pdf (Human Activity Recognition for Video Surveillance)

5.http://www.robots.ox.ac.uk/~lav//Publications/robertson_reid_cviu2006/robertson_reid_cviu2006.pdf (A General Method for Human Activity Recognition in Video)

6. http://mha.cs.umn.edu (Monitoring Human Activity)

7. http:// www.araa.asn.au/acra/acra2004/papers/marzouqi.pdf (Covert Robotics: Covert Path Planning in Unknown Environments)

KEYWORDS: robotics, surveillance, autonomy, image processing, ground vehicle, human activity

A10-144 TITLE: Urban Time-to-Detect Simulator for Vehicle-Developers

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

OBJECTIVE: Establish and validate a new urban signature metric, test protocol, and simulator to allow vehicle designers to evaluate friendly force vehicle signatures in an urban environment. The methodology should allow for the assessment of both measured (existing) and modeled (future) vehicle platforms.

DESCRIPTION: The existing “probability of detection” metrics for both visual and acoustic signatures are based on cold war stand-off battle scenarios. In an urban environment with short ranges and short lines-of-sight, the probability of detection nears 100% in most scenarios. Delaying friendly-vehicle identification and targeting is more important to preventing the detonation of IEDs or the firing of an RPG. This is why a new metric should be developed along with a simulation environment in which to test.

There is no existing simulator sufficient for testing vehicle signatures in an urban environment. Existing simulators might be modified, but specific attention must be paid to the need for very high fidelities to reproduce a field environment detection rate. The offerer will need to investigate which cues are important relative to their new metric and these may include: acoustics, stereoscopic vision, ground vibrations, and others. Also an innovative methodology must be developed to evaluate measured vehicles, purely virtual simulated vehicles, and a hybrid of the two. An example of a hybrid of measured and modeled vehicle data is taking a measured M1 signature and adding a simulated treatment package (camouflage and a silencer) to evaluate against the new metric. Also, research needs to be done to determine a process to predict the acoustic signatures of a full vehicle from its constituent components. The virtual vehicle simulation may leverage existing commercial software and is a critical piece of this topic.

PHASE I: Propose a new metric, test methodology, and design an innovative simulator to allow vehicle designers to improve friendly force vehicle signatures in an urban environment. The metric shall be testable with the developed simulator. Identify and document which psychophysics need to be incorporated into the simulator. At a minimum, evaluate the importance of stereoscopic vision, ground vibration, and acoustics to detection. It is very critical to identify the correct simulator fidelity for each relevant cue. For example, the visual component should consider projector resolution versus eye resolution and the brightness contrast ratio. Assess the hardware and software technologies available to design the described simulator. Define the scope of scenarios and ranges where the simulator would be useful. Select a test scenario that would be a demonstration case in Phase II- the scenario could be any urban environment and the test target could be a commercial vehicle (to avoid classification concerns). A requirements document and implementation plan shall be developed.

PHASE II: Offerer will construct and test full resolution simulator as developed in Phase I. The simulator should allow the government to later input its own backgrounds and vehicles to perform real evaluations. Again the methodology must allow purely virtual vehicles to be constructed. A demonstration of the technology should be performed with at least two moving vehicles. One vehicle will use measured data and the other will be a completely virtual vehicle. Another required demonstration shall be to show one of the vehicles with some sort of acoustic reduction mechanism that subjectively demonstrates the use of the developed metric.

PHASE III: This SBIR topic was presented to OEM DOD contractors for their endorsement. This technology will also be useful commercially for safety studies. Auto industry companies might assess how detectable their vehicle is for the purpose of road safety. Also this would be of high interest to the gaming community since it calls for an immersive environment.

REFERENCES:
1. http://en.wikipedia.org/wiki/Urban_warfare

2. http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA433388

3. http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA390232

4. http://www.wylelabs.com/content/global/documents/3DAcousticSignatureMeasurements.pdf

KEYWORDS: acoustic audio perception signature visual low observable stealth urban mout

A10-145 TITLE: Reduce Thermal/Signature Analysis Cycle Times

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

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

OBJECTIVE: New algorithms are sought to improve thermal multilayer shell software by accelerating computational speed on a general, high density mesh, where the matrix has many elements far off the diagonal (such as encountered in problems involving radiation exchange between surfaces). These thermal algorithms will allow for more accurate infrared signature models which are directly derived from the thermal solutions. Commercially this software will assist with underbody radiation analysis in the automotive industry.

DESCRIPTION: Full vehicle thermal models are very computationally challenging to solve. The current state-of-the-art process is to perform a steady-state computational fluids simulation (CFD) to compute the convection from the fluid-side and then use a separate low-resolution thin-shell model to compute fully transient (in time) wall temperatures. The wall temperature calculation solves conduction and radiation at the walls with imported CFD convection. This process is necessary because it is computationally prohibitive to solve a transient vehicle heating/cooling problem using conventional CFD because time steps as small as 5 minutes over 48 hours of simulated time are typical.

Recent advances in mesh wrapping technologies have reduced model preparation time greatly for the CFD side of the problem, but the shell element solvers still require manual meshing because wrapping does not defeature the model. Since mesh preparation time accounts for up to 90% of the total modeling effort, it is highly desirible to use the high-resolution wrapped CFD mesh for the wall thermal solutions. However, the high resolution mesh solves extremely slowly in a conventional shell element thermal solver.

In order to allow the use of a wrapped high-density mesh and overcome the computational cost, an innovative approach is sought to solve the thermal shell conduction and radiation (with imported convection). This is not trivial because conventional radiation solvers create a matrix with many elements far off the diagonal. Also, the radiation view factor calculation is quite numerically intensive if performed on every wall element.

Finally, if an infrared signature is needed, a high-speed raytracer capable of handling the extremely large surface mesh is desired.

PHASE I: This phase investigate new and innovative high-speed thermal solver algorithms designed to minimize solution times for conjugate heat transfer on polyhedral shell meshes which are very high-density. The offerer will quantitatively demonstrate the efficacy of these algorithms vis a vis existing methodologies on high-density meshes, using both GPU and conventional distributed HPC machines. The algorithms shall solve for surface temperatures by computing conduction, surface radiation, and using imported CFD convection results. At least one command-line transient solver shall be created to demonstrate the most promising algorithm. The solver or solvers may have limited user interaction and is intended simply for proof of concept. A requirements document and implementation plan shall be developed.

PHASE II: The offerer will implement one or more of the algorithms from the plan outlined in Phase I in an existing large-scale computational analysis tool for the design and analysis of vehicular thermal management systems. A demonstration of the capability shall include a model of a typical full ground combat vehicle system that includes multi-physics, and complex three-dimensional geometry with extensive radiative coupling. This phase will demonstrate the feasibility using high density polyhedral CFD meshes for complex thermal surface models, and show the time savings obtained from the advanced solution algorithms and distributed parallel processing.

PHASE III: This highly innovative validated large scale analysis tool developed in phase II would be invaluable to the commercial and military market and Phase III dollars from the MRAP program are assured. Since the currently available tools that rely on lower density meshes have already been commercially successful, this next generation tool has a built-in market in the auto companies, DoD acquisition system designers (such as MRAP contractors), Air Force training programs, the 21st Century Truck plus any industry interested in thermal management. This same process problem as seen in defense has been identified as a particular problem in the automotive industry for radiation dominated problems, such as radiation exchange on an exhaust. The tool produced would help the automotive analysis community greatly.

REFERENCES:
1. http://en.wikipedia.org/wiki/Computational_fluid_dynamics

2. http://en.wikipedia.org/wiki/Parallel_computing

3. http://sbel.wisc.edu/documents/nvidiaOctConference2009.pdf -- Discusses polyhedral, mesh wrapping, and GPUs

4. http://powerlab.fsb.hr/ped/kturbo/OpenFOAM/WorkshopZagrebJan2006/MeshHandling.pdf - Discussion of polyhedral mesh in OpenFoam.

KEYWORDS: thermal management, CFD, ground vehicles, meshing, CAE, finite difference, parallel processing