ARMY
SBIR 09.3 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:

Chris Rinaldi
Program Manager, Army SBIR
army.sbir@us.army.mil

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

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

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.

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

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

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

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

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

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

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

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

A firm-fixed-price or cost-plus-fixed-fee Phase I Cost Proposal ($120,000 maximum) must be submitted in detail online. 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

09.3 Solicitation Pre-release	July 27 – August 23, 2009
09.3 Solicitation Opens	August 24 – September 23, 2009
09.3 Solicitation Closes	September 23, 2009; 6:00 a.m. ET
Phase I Evaluations	September – December 2009
Phase I Selections	December 2009
Phase I Awards	January 2010*

**Subject to the Congressional Budget process*

PHASE II PROPOSAL SUBMISSION

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. Invitations to submit Phase II proposals will be released at or before the end of the Phase I period of performance. 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, repeated below:

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c. The potential for commercial (defense and private sector) application and the benefits expected to accrue from this commercialization. The Army exercises discretion on whether a Phase I award recipient is invited to propose for Phase II. Invitations are issued no earlier than completion of the fourth month of the Phase I contract award, with the Phase II proposals generally due one month later. In accordance with SBA policy, the Army reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards.

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

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

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

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

Beginning in the DoD 2006.2 SBIR solicitation, offerors are instructed to include an estimate for the cost of complying with CMRA as part of the cost proposal for Phase I ($70,000 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

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

ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 09.3 Topic Index

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

A09-124	Aviators Intelligent Assistant
A09-125	Advanced Turboshaft Engine/Drivetrain Modeling Technique for Real Time Rotorcraft Simulation

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

A09-126	Nano-Lubricant/Fluid for Improved Weapons System
A09-127	FPGA Low Power Design Rules
A09-128	The Behavior within Minimum Signature Propellants during Impact IM Tests
A09-129	Innovative Sensor to Measure Detonation Properties of Propellants and Explosives
A09-130	Enhancement of Penetration Capability of Light Warheads Into Hardened Walls.
A09-131	Quantitative Back-Annotation of Simulink Models for Hardware Synthesis Optimization
A09-132	Automated Preparation of Geometry Models for Computational Applications
A09-133	Power-On Missile Stage Separation Simulation
A09-134	Air-Breathing Missile Thrust Measurement

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

A09-135	Innovative Inertia Devices
A09-136	Multispectral Gamma Detector for Explosives Analysis
A09-137	Fast-Impulse Solid Fuel Miniature Thruster

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

A09-138	Multi-Threaded Missions and Means Framework
A09-139	Capacitor thermal management for mobile power electronics
A09-140	Ballistic Shock Mitigation Materials and Technology for protective system
A09-141	Mitigating Optical Turbulence using a Real-time Image Restoration Processor

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

A09-142	Realistic Communications Effects for Evaluation of Tactical Command and Control and Situational Awareness applications
A09-143	Inertially Stabilized Smart Camera
A09-144	Microfabricated Mass Spectrometer for Near Real-Time Toxic Chemical Detection

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

A09-145	Advanced Readout Development for High Performance Corrugated Quantum Well Infrared Photoconductors Technology
A09-146	Proactive Automatic Information Requests
A09-147	Helmet Mounted Radar System (HRMS)
A09-148	Tunnel Detection using MASINT Techniques
A09-149	Visual Measurement Based Autonomous Navigation
A09-150	Problem Conceptualization & Resolution of Network Problems in Tactical Environment
A09-151	In-situ Stress and Temperature Optical Monitoring for low-cost heteroepitaxial substrates for HgCdTe infrared detectors.

Medical Research and Materiel Command	**J.R. Myers**	**(301) 619-7377**

A09-152	Develop a Point-of-care Antigen Assay for Rickettsial Early Diagnosis
A09-153	Wearable Fiber Optic-Enabled Chemical Nanosensor Array for Warfighters
A09-154	In Vivo Stem Cell Extraction Device
A09-155	Development of a Simple and Rapid Assay for Field Detection of Dengue Viral RNA

A09-156 Development of a Multiplex Hand-held, Field-deployable Assay for the Detection of Tick-borne Encephalitis Virus (TBEV), Crimean-Congo Hemorrhagic Fever Virus (CCHFV), and Rickettsia in Ticks
A09-157 Portable Device for Noninvasive Quantization of Post Traumatic Stress Disorder (PTSD) and Mild Traumatic Brain Injury (M-TBI)
A09-158 Development of New Repellent Application Techniques for Military Clothing
A09-159 Apparatus for Non-Invasive Estimation of Arterial Carbon-Dioxide Content for Ventilation of Combat Casualties

Natick Soldier Research, Development & Engineering Center **Gerald Raisanen** **(508) 233-4223**

A09-160 Innovative Microclimate Cooling Technology
A09-161 Novel In-Line Water Purification System
A09-162 Thermoelectric Subsytem for Self-Powered Equipment
A09-163 Automated Data Recording Technology for Assessing Parachute Performance and Use
A09-164 Lightweight Bomb Suit Face Shield
A09-165 Washable Wool Products for Individual Protection
A09-166 One-Time Use Parafoil
A09-167 Biomimetic-based Flame Retardant Materials for Combat Uniforms and Equipment: Coatings/Fibers Developed from Sustainable and Green Processes
A09-168 Antimicrobial Coatings for Medical Shelters
A09-169 Lightweight, Flexible Ballistic Protection System for Arc Shaped Shelters

Program Executive Office Command, Control and Communications Tactical **Christopher Shin** **(732) 427-0284**
Vikas Gumber **(732) 427-2205**
Grace Xiang **(732) 427-0284**

A09-170 Situational Awareness for Ad-hoc Tactical Networks (SAATN)
A09-171 Scalable Discrete Event Simulations of Asynchronous Dynamic Systems on Massively Parallel Multi-Core Computers for MANET

Program Executive Office Combat Support & Combat Service Support **Robert LaPolice** **(586) 909-9945**

A09-172 Enterprise Logistics Data Mining & Integration Expert System
A09-173 Smart Sensor Network for Platform Structural Health Monitoring

Program Executive Office Ground Combat Systems **Peter Haniak** **(586) 574-8671**
Jose Mabesa **(586) 574-6751**

A09-174 Personal Protective Equipment-Integrated Restraints for Blast Mitigating Seats
A09-175 Development of Silicon Based Lithium-ion Battery Technology

Program Executive Office Intelligence, Electronic Warfare & Sensors **Bharat Patel** **(410) 273-5484**
Rich Czernik **(410) 273-5406**

A09-176 Flat Panel Shelter-Mountable Phased Array Antenna for DoD Systems of Record

Program Executive Office Simulation, Training and Instrumentation **Robert Forbis** **(407) 384-3884**

A09-177 High Off-Boresight Angle Icing Cloud Characterization Probe

PM Future Combat Systems Brigade Combat Team **Fran Rush** **(703) 676-0124**
Philip Hudner **(703) 676-0082**

A09-178 Development of High Power Lithium-ion Batteries

Space and Missiles Defense Command **Denise Jones** **(256) 955-0580**

A09-179 Phasing Multiple High Power Impulse RF Sources
A09-180 High Performance Power Generation for High Altitude Platforms

Simulation & Training Technology Center		**Thao Pham**	**(407) 384-5460**
A09-181	Dynamic Formats in Distributed Simulation Systems		
A09-182	Terrain Database Correlation and Automated Testing Technologies		

Tank Automotive Research, Development & Engineering Center		**Jim Mainero** **Martin Novak**	**(586) 574-8646** **(586) 574-8730**
A09-183	Real Time Damage Monitoring of Composite Vehicle Armor Structure Integrity Using Embedded Sensors		
A09-184	Innovative Wheel Control Technologies for Mechanical Counter Mine Equipment		
A09-185	High Pressure Layflat Hoseline		
A09-186	Improved Tele-Control for Manipulator Equipped Unmanned Ground Vehicles		
A09-187	Semi-Autonomous Manipulator Control		
A09-188	Teleoperation with High Latency		
A09-189	Transducer Technologies for Track Health Monitoring		
A09-190	Advanced Condition Based Maintenance (CBM) Characterization Using Data Fusion Techniques		
A09-191	Vehicle Blast Data Recorder		
A09-192	System Design Optimization Model		
A09-193	Variable Speed Alternator Drive		
A09-194	Army Ground Vehicle Thermodynamic Waste Heat Recovery System		
A09-195	Highly Accurate Active Optical Sensor - Proximity Fuze		
A09-196	Autonomous Indoor Mapping and Modeling		
A09-197	Durability Modeling and Simulation of Composite Materials		
A09-198	Fatigue Life Modeling & Simulation of Elastomer-Polymer Materials		
A09-199	Ultra High Pressure Jet Propellant-8 (JP-8) Fuel Injection		
A09-200	Advanced Battery Management System Development (including advanced prognostic and diagnostic capability)		
A09-201	Lower Life Cycle Cost, High Strength Heat Resistant Polymers for Track Bushing & Pads		
A09-202	Enable the Main Vehicle Engine to Operate Efficiently in Silent Watch Services at 15 to 20% of its rated power		
A09-203	Vision-Based Motion Sensing for Small Unmanned Ground Vehicles		
A09-204	Standards Based Unmanned Ground Vehicle Mission Language Translator with Graphical Planning Tool		

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

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

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

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

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

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

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

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

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

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

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

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

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A09-165	Washable Wool Products for Individual Protection
A09-166	One-Time Use Parafoil
A09-167	Biomimetic-based Flame Retardant Materials for Combat Uniforms and Equipment:

Coatings/Fibers Developed from Sustainable and Green Processes

A09-168	Antimicrobial Coatings for Medical Shelters
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A09-194	Army Ground Vehicle Thermodynamic Waste Heat Recovery System
A09-195	Highly Accurate Active Optical Sensor - Proximity Fuze
A09-196	Autonomous Indoor Mapping and Modeling
A09-197	Durability Modeling and Simulation of Composite Materials
A09-198	Fatigue Life Modeling & Simulation of Elastomer-Polymer Materials
A09-199	Ultra High Pressure Jet Propellant-8 (JP-8) Fuel Injection
A09-200	Advanced Battery Management System Development (including advanced prognostic and diagnostic capability)
A09-201	Lower Life Cycle Cost, High Strength Heat Resistant Polymers for Track Bushing & Pads
A09-202	Enable the Main Vehicle Engine to Operate Efficiently in Silent Watch Services at 15 to 20% of its rated power
A09-203	Vision-Based Motion Sensing for Small Unmanned Ground Vehicles
A09-204	Standards Based Unmanned Ground Vehicle Mission Language Translator with Graphical Planning Tool

Army SBIR 09.3 Topic Descriptions

A09-124 TITLE: Aviators Intelligent Assistant

TECHNOLOGY AREAS: Air Platform, Information Systems, Electronics, Human Systems

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop a decision making device, Aviation Intelligent Agent, to be incorporated into a cockpit environment providing both contextual and graphic information/solutions to reduce the already overloaded flight crews.

DESCRIPTION: Mission execution is a complex event, in dynamic environments requiring rapid decision-making capabilities while inducing enormous amount of stress and additional burdens on the flight crews. Flight crews are already overloaded with normal activities: crew management, ensuing situation awareness, platform health, mission priorities, and etc. With new technologies evolving we are constantly increasing crews workload by adding new systems to the airframes and associated systems. This overloading of activities can cripple a flight crew resulting in loss of the resource or even worst loss of the crew and platform.

A proposed solution is to design and develop an automated Aviators Intelligent Assistant that will complement the air crews. It will integrate into the flight deck environment and yet will not induce additional burden or distraction. This device will have the ability to interact with both battle command management and crew activities to provide some sort of decision matrix. The system should convey both textural and graphic information utilizing a high performance computing genetic programming process for solutions.

Critical information that must be accounted for but not limited to: information relevant to the current location, mission plan and directives, monitoring the critical sensor systems/networks associated with the aircraft, tracking critical decision points related to mission success and notifying the crew when requirements are method or reminding them of decision point before it is missed and finally having the ability to track and interpret where natural/friendly forces are in the battle space.

We are searching for an intelligent decision making solution that can work within current or soon-to-be-deployed onboard tactical information systems, such as the Engine Instrument Caution Advisory System (EICAS), the Flight Director/Digital Control Panel (FD/DCP) or Tactical Airspace Integration System (TAIS) and can be tested and integrated in virtual cockpits prior to being transitioned to real aircraft. Core requirements for such a technology include the ability to model and respond to changes in aircrew context including location and mission status information, incorporate direction from the air crew, and manage and/or perform information configuration and presentation processes.

Our intention is to develop the intelligent decision capability first than integrate it into the airframes. However, keep in mind that the developed system will need to be flight certified.

PHASE I: Design and determine the feasibility of mission-relevant information decision-making device, Aviators Intelligent Agent. This agent should have the capabilities to interface and communicate with battle command, sensor systems/networks and airframe computers providing the air crews with solutions and options to better execute their mission.

PHASE II: Develop a prototype tool and hardware to integrate the Aviators Intelligent Agent into the AMRDEC APEX lab at Redstone Arsenal. The device should incorporate both graphical and textual information to provide solutions and options to the crew.

PHASE III: The proposed system has applications in both military and commercial domains. The resultant prototype can be transitioned, with assistance from the Army customer, to display systems on fielded C2 vehicles/platforms requiring human operators to reason about large amounts of diverse information. In the commercial market, this prototype could be transitioned to existing commercial helicopter cockpit interfaces. Furthermore, the intelligent interface concept could be extended to improve scores of existing technologies featuring real-time displays that interact with the user (GPS/navigation displays, smart-phones, etc.).

KEYWORDS: information delivery, intelligent assistant, cognitive decision aids, information overload, intelligent agents, pilot workload, crew situational awareness

A09-125 TITLE: Advanced Turboshaft Engine/Drivetrain Modeling Technique for Real Time Rotorcraft Simulation

TECHNOLOGY AREAS: Air Platform, Information Systems, Space Platforms

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 effort is to develop an innovative and advanced modeling technique for turboshaft engine/drivtrain dynamics capable of supporting real-time rotorcraft flight simulation. The resulting modeling technique shall be of a generic architecture and not specific to a particular vendor (i.e. engine or airframe manufacturer).

DESCRIPTION: Current state-of-the-art turboshaft engine and drivetrain models are custom built models specific to a particular engine and simulation application. The engine thermodynamics model requires a significant amount of empirical transient engine performance data used in a table lookup format. For drivetrain dynamics, a single rotational degree of freedom (DOF) is typically utilized. In reality, rotorcraft drivetrain dynamics involves multiple DOFs. Even for the simplest configuration, a conventional single main rotor and tail rotor, there are main gearbox dynamics and a tail rotor drive system which have multiple distinct frequencies and various transient characteristics. This approach suffers from inaccuracy in modeling the engine/drivetrain dynamics during transient states. The need for empirical data and the inaccuracy during transient behavior means the current modeling techniques cannot be used for preliminary aircraft performance evaluations.

Advancement in state-of-the-art rotorcraft models now generates the requirement for a new advanced approach to modeling engine/drivetrain dynamics. This is due to the fact that the engine and drivetrain dynamics are closely coupled with the main/tail rotor dynamics and strongly impact the aircraft transient response. This is especially true for modern rotorcraft that are equipped with Full Authority Digital Engine Control (FADEC) systems. A modern FADEC tightly couples the engine/drivetrain and rotor/airframe dynamics, both of which are also coupled with modern flight control systems. Previous rotorcraft models lacked the fidelity to accurately model helicopter performance during aggressive transient maneuvers, restricting the models application, and therefore idealized engine models (i.e. no engine dynamics) were sufficient for preliminary design.

The lack of availability of accurate transient engine data in the early phases of the acquisition process can lead to redesigns later in the design process causing delays and cost increases. Development of a high fidelity modeling tool that can support real time simulation of the coupled rotors/engine/drivetrain/flight control system is essential for designing new rotorcraft or upgrading existing aircraft.

PHASE I: The objective of the Phase I effort is to develop a physics-based formulation to model turboshaft engine thermodynamics and drivetrain dynamics without relying on empirical transient performance data. Given time dependant inputs such as fuel flow and atmospheric conditions, this model shall generate the resulting engine/drivetrain time-dependant response. In addition, a feasibility study to incorporate the solution into an industry standard rotorcraft simulation program shall be completed.

PHASE II: The objective of Phase II is to fully implement the physics-based engine thermodynamics model and the coupled engine/drivetrain/rotor dynamics in a high fidelity real time rotorcraft simulation. Test and validate the simulation with Army helicopters.

PHASE III: The objective of Phase III is to develop simulation applications with the advanced modeling methodology and provide a final software package and demonstrate the functionality to government engineers. It is anticipated that these models will be incorporated into engineering development simulators during the preliminary design phase as well as training simulators. Given that this methodology can accurately simulate the transient thermodynamic and drivetrain dynamics, this will greatly improve design optimization in all phases of procurement, expand the role and effectiveness of both commercial and military simulators used for procedural and proficiency training as well as desktop simulation design analysis, design optimization and simulation based acquisition.

DUAL USE APPLICATION: The advanced turboshaft engine and coupled drivetrain modeling technique can serve as a useful design and evaluation tool for both rotorcraft and turboshaft engine manufacturers of commercial and military systems. The modeling functionality can also be effectively utilized for full rotorcraft simulation and provide valuable simulation support throughout the rotorcraft acquisition, design, engineering, and testing life cycle.

REFERENCES:
1. NASA Contractor Report 166309, "UH-60A Black Hawk Engineering Simulation Program: Volume I Mathematical Model", December 1981.

KEYWORDS: Turboshaft Engine, Engine Thermodynamics, Rotorcraft Simulation, Unmanned Air Vehicles

A09-126 TITLE: Nano-Lubricant/Fluid for Improved Weapons System

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: This topic's primary objective is the development and demonstration a nano-lubricant/fluid to significantly reduce gear erosion wear on Army missile weapon systems, with a secondary objective to significantly improve system heat transfer.

DESCRIPTION: The Army has a need for nano-lubricants/fluids that increase the reliability, readiness, and survivability of its weapons systems while reducing the sustainability and maintenance. The harsh conditions in the current operating environment, such as extreme high temperatures, have hampered missile weapon system performance, impacting drive train and turbine power efficiency on systems such as the Abrams tank, and the M270 and HIMARS vehicles. More heat removal would result in smaller coolers and less weight, thus increasing the weapon system's survivability by reducing the heat signature.

PHASE I: The Phase I objective would involve the development of formulas and technology transfer strategies to implement a nano lubricant/fluid on a variety of Army missile weapon system engines, transmissions, and other gears. The contractor should demonstrate the ability to produce significant quantities for testing. Following testing, the contractor should define overall impacts and improvements to missile weapon system survivability, maintenance, reliability and sustainability. The contractor should understand environmental and safety concerns, as well as, propose methods to address these concerns. Also, need to define disposal issues concerning Environmental, Safety, and Occupational Health and any special disposal costs. Define metrics that will be used to show improvements that will be demonstrated in Phase II.

PHASE II: The Phase II objective will be to develop nano lubricants/fluids, apply them, and test/demonstrate their capabilities. The developed nano lubricants/fluids with the nano-additive should be compared to a baseline fluid that does not contain nano-additives. The comparison will be A to B (i.e. under identical testing conditions and loads). Measurements will include power transfer loss by %, heat rejection deltas, fluid breakdown results (i.e. longevity of the fluid). The comparisons will be direct of one fluid versus the other. Accomplishment of greater than 5% increase in power transfer and heat rejection increases of 1% or greater versus the baseline fluid will be considered a success. Also, tribological studies of wear patterns of the gears being tested could be performed. An oil analysis will reveal the degradation of each fluid studied, environmental disposal concerns, and wear metals entrapped in the fluid. Testing needs to show these nano lubricants/fluids can significantly improve Army missile weapon system survivability, maintenance, reliability and sustainability.

PHASE III: In addition to the use on Army missile weapon systems, these nano lubricants/fluidss could be used on Army aircraft systems. Potential uses for the lubricants are the Apache engine and drive trains. The commercial application has huge potential since the auto industry could greatly benefit from a motor or gear lubricant that significantly improves fuel economy and increases lubricity. An example of an aircraft system application could be on the cooling system for the Apache Block 3 nose gearbox. A commercial application could be for the differential that requires a cooler.

REFERENCES:
1. Nanotribology and Lubrication Mechanisms of Inorganic Fullerene-Like MoS2 Nanoparticles Investigated using Lateral Force Microscopy, J.J Hu and J.S Zabinski, Air Force Research Laboratory, Tribology Letters, Vol. 18, No. 2, February 2005.

No other public references are available.

KEYWORDS: lubricant, gear, transmission, engine, additive, drivetrain, heat transfer, heat removal, transmission, engine, cooler

A09-127 TITLE: FPGA Low Power Design Rules

TECHNOLOGY AREAS: Information Systems

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: Contractor shall develop a field programmable gate array (FPGA) synthesis tool plug-in software application and a set of design rules to reduce power consumption of commercial field programmable gate arrays.

DESCRIPTION: The purpose of this SBIR is to develop a FPGA synthesis plug-in application software tool to significantly reduce the power consumption of commercial field programmable gate arrays.

Commercial FPGA programming software tools use a FPGA synthesis tool to route the connections between logic gates, look-up tables, and random access memory (RAM). A design rules file is used by the FPGA synthesis tool to connect the elements together within the design specifications for the FPGA. The road map contained in the design rules configuration file provides the FPGA synthesis tool with the intelligence required to compile the FPGA high level language hardware description and route the programmable connection fabric for the FPGA. Current commercial tools are optimized to maximize operation speed, and minimize logic gate count, look-up tables, amount of RAM required, etc.

We are interested in the development of a FPGA synthesis plug-in software application tool that will minimize FPGA power consumption instead of the traditional approach of minimizing gate count, Look-up Tables (LUT), etc. In order to develop a FPGA synthesis tool to minimize power consumption, the contractor shall develop a set of design rules to minimize power consumption. The FPGA synthesis plug-in software application tool shall utilize the design rules to compile and FPGA high level language hardware description into a FPGA binary file (hardware equivalent of a software executable file).

Contractor shall deliver (1) FPGA synthesis plug-in application software tool and low power design rules, (2) two FPGA evaluation boards, and (3) any required commercial FPGA software tools to the government point of contact.

PHASE I: Contractor shall research the feasibility of developing (1) a FPGA synthesis plug-in software application tool, and (2) programming design rules to reduce power consumption for FPGAs by an order of magnitude over commercial specification.

Contractor shall research how gate count at 0%, 20%, 50%, 70%, and 100% FPGA gate count affects the power consumption of an FPGA.

Contractor shall research the feasibility of FPGA synthesis plug-in application software tool(s) for either a single device, a family of devices, or for multiple FPGA manufacturers. Contractor shall research the feasibility of developing a set of design rules to minimize FPGA power consumption. The design rules shall provide the intelligence for the FPGA synthesis plug-in application software tool.

Contractor shall provide a report describing how the FPGA synthesis plug-in application software tool(s) will utilize the low power design rules to compile a digital system described by Very High Level Design Language (VHDL), High Level Design (HDL), Verilog, System Verilog, etc. into a programmed FPGA. Contractor shall provide a final report describing the FPGA synthesis software tool, roadmap described the low design rules, and any required support hardware.

PHASE II: Contractor shall develop a prototype (1) FPGA synthesis plug-in application software tool and (2) the low power design rules.

Contractor shall have an independent lab test and evaluate the FPGA synthesis tool and low power design rules. Contractor shall provide a copy of the test and evaluation report to the government.

Contractor shall deliver (1) FPGA synthesis plug-in application software tool and low power design rules, (2) two FPGA evaluation boards, and (3) any required commercial FPGA software tools to the government point of contact. Contractor shall provide a preliminary performance description for the FPGA synthesis plug-in software tool. Contractor shall provide a final report describing the FPGA synthesis plug-in software tool. Contractor shall provide a 2 day on site training for the FPGA development/synthesis/debugging toolset, and integrated development environment.

PHASE III: Contractor shall team with a commercial FPGA tool vendor to incorporate the FPGA synthesis tool targeted towards low power applications into a commercial FPGA integrated development environment.

Military embedded computers using FPGAs will benefit from lower power consumption. Contractor shall investigate the potential of a commercial version of the FPGA synthesis tool targeted towards low power applications. Commercial electronics, particularly battery power devices, will benefit from the flexibility of FPGAs and the lower power consumption provided by the low power design rules.

REFERENCES:
[1] C. Weisheng, et al.: ï¿½Low-power field-programmable VLSI processor using dynamic circuits,ï¿½ IEEE Computer society Annual Symposium on VLSI, pp. 243 ï¿½ 248, Feb. 2004.

[2] E. Monmasson, and M. Cirstea: FPGA Design Methodology for Industrial Control Systems - A Review, IEEE Transactions on Industrial Electronics, Vol. 54, Issue 4, pp. 1824-1842, Aug. 2007.

[3] M. Marik, and A. Pal: High Performance and Low Power Synthesis Approach for ACTEL based FPGAs, IEEE Region 10 TENCON, pp. 1-6, Nov. 2005.

[4] G. Garcia, et al.: Reducing the power consumption in FPGAs with keeping a high performance level, IEEE Computer Society Workshop on VLSI, pp. 47-52, April 2000.

[5] K. Paulsson, et al.: Cost-and Power Optimized FPGA based System Integration: Methodologies and Integration of a Low-Power Capacity-based Measurement Application on Xilinx FPGAs, Design, Automation and Test in Europe, pp. 50-55, March 2008.

[6] P. Leong: Recent Trends in FPGA Architectures and Applications, IEEE International Symposium on Electronic Design, Test and Applications, pp. 137-141, Jan. 2008.

KEYWORDS: FPGA, low power, design rules, field programmable gate array, FPGA synthesis

A09-128 TITLE: The Behavior within Minimum Signature Propellants during Impact IM Tests

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: The objective of this topic is to develop a model that accurately predicts the violent behavior of minimum signature, Class 1.1 (detonable) propellants to bullet impact (BI), fragment impact (FI), and shaped charge jet (SCJ) Insensitive Munitions (IM) threats.

DESCRIPTION: Several incidents that resulted in significant loss of life and property, including the one on the Forrestal during the Viet Nam conflict, and more recently Camp DoHa, demonstrated that bombs and missiles are susceptible to bullet and fragment impact, slow and fast cook-off, sympathetic detonation, and shape charge jet threats. MIL-STD-2105C outlines the Insensitive Munitions program that requires all warheads, explosives, and propulsion systems to comply with its requirements (no reaction more severe than burning) or get waivers while they work toward meeting their requirements.

US Army Aviation and Missile Commands Safety Office is developing a model to predict the response of conventional high performance, non-detonable Class 1.3 propellants to BI, FI, and SCJ threats; however, there has been little effort in modeling the detonable Class 1.1 minimum signature propellants. The Physical and chemical properties of 1.3 propellants, that have hydroxy-terminated polybuatadiene-based binders, are significantly different than those for 1.1 minimum signature propellants with nitrocellulose-based binders. The model for 1.3 high performance propellants, therefore, cannot accurately predict the response of Class 1.1 minimum signature propellants to these IM threats.

PHASE I: The goal of Phase 1 is to establish the hypotheses that will be the backbone of the model. This includes developing a top-level understanding of the physics and chemistry occurring during the impacts of the three threats into the propellant and collecting experimental sub- and full-scale IM data. A detailed outline of the model will be prepared that describes the planned Phase II effort, and the approach to be taken.

PHASE II: The full model that was outlined in Phase I will be developed during Phase II. This model will incorporate state-of-the-art physics and chemistry understanding into the model. The necessary mechanical models, or equations of state needed as input to the analysis will be defined.The existing sub- and full-scale IM data base will be used to validate the model. At the end of Phase II, the model will be capable of predicting the behavior of a propellant formulation, in a motor configuration, provided by the Army, in a sub-scale FI test. Using data obtained from an experimental sub-scale FI test, the contractor will compare the prediction to the experimental results to provide further validation.

PHASE III: Fabricate, package, test and demonstrate the technology into a commercial system. This sensor system will be of great interest in the testing community. It will measure temperature at microsecond time frams. Standard thermocouples, can not respond in the very short time-frames required. It will be able to measure pressure in ways that are not possible with conventional pressure transduces and they even have a chance of replacing existing transducers at energetic testing facilities.

REFERENCES:
1. Sutton, Georg P., and Biblarz, Oscar, Rocket Propulsion Elements, Seventh Edition, John Wiley & Sons, Inc. New York. 2001.

2. Mader, Charles L. Numerical Modeling of Detonations. UniversityOf California Press. 1979.

3. Bullet and Fragment Impact Hazards To Solid Rocket Motors, Selected Papers The John Hopkins University. CPIA Pub. SP 92-06

KEYWORDS: Insensitive Munitions; solid propellants; minimum signature propellants; Class 1.1 propellants; bullet impact tests; fragment impact tests; shaped charge jet tests; Insensitive Munitions; detonation, hydrocodes.

A09-129   TITLE: Innovative Sensor to Measure Detonation Properties of Propellants and Explosives

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 a sensor system that is capable of being inserted into a propellants and explosives to measure the velocity, position, pressure and temperatures of the deflagration/detonation wave associated with ignition of energetic materials.

DESCRIPTION: In the early stages of detonation, the behavior of any explosive during the dynamic transition from early low-order detonation up to the full-order detonation at nominal detonation velocity is critical in determining the robustness of the initiation and detonation process. This duration of transient detonation velocity change is commonly referred to as dynamic shock detonation and these transients scale to very short times and distances for ideal explosives. The transients in non-ideal propellants and explosives scale to longer times and distances. Experimental techniques that measure a continuous change in detonation velocity provide insight into this dynamic regime of initiation physics. Continuous velocity measurements are significantly more accurate in determining this run-up in velocity relative to single point measurements (such as ionization pins or piezoelectric shock pins), which yield only the average velocity measurement between the individual pin placement points. Additional information provided by pressure and temperature measurements performed during this process would enable a new and powerful diagnostic tool for improving the performance of highly energetic materials. The data obtained by innovative sensors can be used to validate models that predict propellant and explosive behavior during Insensitive Munitons treats. It is important that any new diagnostic tool for energetic systems be intrinsically safe.

PHASE I: Develop and design approach for a measurement system that can be used externally or internally with energetic material. This system will measure key parameters associated with a blast wave including velocity, position, pressure and temperature. Demonstrate the feasibility of the proposed approach and evaluate it with respect to stated performance objectives. These tests will demonstrate the difference between materials that deflagrate and those that detonate.

PHASE II: Design, fabricate, package, test and demonstrate a prototype system that can be embedded into highly energetic material and used to support measurement of the velocity, position, pressure and temperature associated with blast waves associated with detonating material. This system will be used to characterize existing propellants and explosives to demonstrate the ability to obtain accurate and reliable data that can be used to validate theoretical models.

PHASE III: Fabricate, package, test and demonstrate the technology into a commercial system. This sensor system will be of great interest in the testing community. It will measure temperature at microsecond time frams. Standard thermocouples, can not respond in the very short time-frames required. It will be able to measure pressure in ways that are not possible with conventional pressure transduces and they even have a chance of replacing existing transducers at energetic testing facilities. Dual use applications include other transportation modes that have the potential for sudden catastrophic failures, such as black boxes in aircraft or commercial missiles for satellite insertion or commercial maned space flight. These sensors would be linked to the black boxes from critical areas such as motors, engines, and ejection seats. Automobile air bag manufacturers could be interested because the response from this sensor willl have a faster response than current sensors.

REFERENCES:
1.TB 700-2 Department of Defense Ammunition and Explosives Hazard Classifiation (newest revision)

2.MIL-STD-1751A (or newest revision) Department of Defense Test Method Standard Safety and Performance Tests of the Qualification of Explosives (High Explosives, Propellants, and Pyrotechnics)

3.49 CFR Title 49 Hazardous Material Regulations (newest revision)

4.MIL-STD-2105C (or newest revision) Department of Defense Test Method Standard Hazard Assessment Tests for Non-Nuclear Munitions (Insensitive Munitions Standard)

KEYWORDS: velocity, temperature, and pressure sensors; detonation; deflagration; propellants; explosives; Insensitive Munitions

A09-130 TITLE: <u>Enhancement of Penetration Capability of Light Warheads Into Hardened Walls.</u>

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: The objective of this topic is to develop and demonstrate novel technologies that can be used to enhance the penetration capabilies of light weight warheads and allow for a follow through warhead to enter a masonry structure.

DESCRIPTION: The modern day targets have shifted away from tanks and armored vehicles to Urban Structures. These operations are called MOUT, Military Operations in Urban Terrain. We have an extensive inventory of man portable weapons, using shaped charges, that can be used to defeat tanks and armored vehicles but that threat has greatly diminished and the new threat is MOUT targets. The shaped charged warheads can penetrate the MOUT structures but unlike inside a tank they do not provide a substantial incapacitation of personnel inside that structure. They make a very small hole inside the structure and as long as you are not unlucky enough to be standing right where the shaped charge hits, you will walk out of the structure unharmed. For that reason a new class of shoulder launched weapons has been in development. These weapons are called ASM, Anti Structural Munitions. How they work is that they penetrate inside the structure where the warhead will then detonate and they use blast over pressure to provide the lethality. The blast over pressure will provide lethality by three different mechanisms. Primary blast lethality is caused by the over pressure working on the human body directly resulting in injuries like blast lung.

Secondary blast lethality is caused by the blast overpressure throwing debris or the building collapsing on top of combatants inside. Tertiary blast lethality is caused by the blast over pressure picking the combatants up and throwing them against walls or floors.

Presently, our shoulder launched weapons that are designed for MOUT targets, are very effective at penetrating and neutralizing single brick and brick over block structures but are not effective at penetrating or breaching harder targets. The class of shoulder launched weapons of initial interest here are the LAW Anti Structural Munitions, SMAW, SMAW D, Carl Gaustav and AT-4 weapon systems. Presently all of these weapon systems do have Anti Structural warheads but the limit of those warheads is that they cannot penetrate Double Reinforced Concrete, DRC, and double or triple brick. For these types of targets the soldiers have to call in artillery support.

CBA Report Dated 06 July 2005 identifies a capabilities gap that still needs to be filled. That report states the follow requirements exist to Incapacitate personnel protected by urban structures (DRC, Double and Triple Brick), within an earth & timber bunkers, protected by stone bunkers (HEL TM 30-78), protected by fighting positions within buildings, and within a stationary or moving (15 kph) Light Armored Vehicle (30 mm RHA). Additionally the CBA Report sets weight requirements that the new weapon system weigh less than 15 pounds which puts this effort in the LAW or SMAW size weapon.

Current shaped charge designs are very effective at creating a very deep but very small diameter hole. As a rule of thumb a 1 diameter Shaped charge will create a 0.3 diameter hole in Rolled Homogeneous Armor that can be feet thick. This is good when you want to defeat a tank but not very effective against brick or concrete structures. Even with a 3 diameter shaped charge you will only get a 1 diameter hole and that will not allow you to effectively get a follow through round inside the structure. To get the follow through round inside the structure a precursor charge that can soften the concrete or create a much larger hole needs to be developed.

The requirements for the shoulder launched weapon system are that the entire system weight be 15 pounds or less, less than 32 carry length and effective against targets listed in the 06 July CBA Report. The anticipated weight of the follow through round is 2-3.5 pounds with a final velocity in the 350-500/ sec range. This leaves a budget for the warhead section, including the follow through of 3-5 pounds. Of that 3-5 pounds 1-1.5 pounds can be used for the precursor charge. Due to the limit on system weight the anticipated system size will be a 66 - 83 mm round.

What we are looking for are novel concepts in the 1-1.5 pound range that will soften an area of concrete with a diameter of 66-83mm and up to 12 thick to allow the follow through round to penetrate the target.

Once this technology has been developed, tested and matured for the light weight shoulder launched systems it can be easily transitioned into much larger systems Hellfire or Javelin in enhance their penetration capabilities.

PHASE I: Proof of Concept: The goal of Phase I is to develop and test promising technologies to accomplish this mission. This will include the manufacture of charge designs, modeling and static testing to show Proof Of Concept that the new technology has the potential to penetrate the targets and would be weaponizable in a light weight shoulder launched weapon. It is envisioned that several concepts will be evaluated for their penetration or softening capabilities and that the most promising will be awarded a Phase II effort.

PHASE II: Development and Demonstration: The goal of Phase II would be to mature the technology and to demonstrate, in a prototype warhead, that the new technology does enhance the penetration capability and delivers a follow through payload of sufficient size to incapacitate personnel inside the structure. The plan would be for the SBIR business to team with a commercial weapons manufacturer to conduct a live demonstration of their new warhead penetration concept. This demonstration would include the precursor warhead attached to an inert follow through round and integrated into one of the existing shoulder launched weapon system. The Threshold for success would be to be able to penetrate double brick with the follow through round and the objective would be to penetrate DRC and Triple Brick.

PHASE III: Weaponization: This effort will be for the transition of the new warhead technology to a commercial weapons manufacturer, weaponization, System level live fire tests, and qualification of the new warhead for soldier use. There are two main domestic commercial weapons manufactures for this class of weapon system. Those are Talley Defense Systems for the LAW and SMAW systems and ATK for the Carl Gaustav and AT-4. Tally Defense

Systems would be the preferred vendor because they actually own both the LAW and the SMAW systems where as ATK only has a licensing agreement with Bofers for the AT-4 and Carl Gaustav. This technology could be used by Search and Rescue teams to allow them to quickly punch holes in walls of a collasped building or structure and allow for a camera, air tube or listening device to be inserted in the hole created by the precursor charge. In natural desaster events like earthquakes accessing inside a collasped structure is very time consuming and dangerous. They often have to wait for heavy equipment to move debris or drill through the walls. Use of the precursor charge would enable much quicker access inside the collasped building so that anyone traped can receive help faster.

REFERENCES:
1. CBA Report for Close Combat Weapons, dated 06 2005

KEYWORDS: Penetrating warheads, breaching hard targets, shaped charge, follow-through, unitary warheads, tandem warheads

A09-131 TITLE: Quantitative Back-Annotation of Simulink Models for Hardware Synthesis Optimization

TECHNOLOGY AREAS: Information Systems, Weapons

OBJECTIVE: The objective of this program is to develop a tool for back annotating Simulink models used for hardware design with timing, area, and power information from the as-built system for use by subject matter experts performing optimization.

DESCRIPTION: Model Based Design and Implementation (MBDI) of computational systems is an evolving discipline whose goal is to allow subject matter experts (SME) to take a simulation model directly into a hardware implementation without utilization of design phases. The goal of MBDI is to have the model developed by SME be the design for the final implementation. MBDI will significantly reduce risk, lower cost, and accelerate life-cycle management of computationally based systems. It reduces the number of design cycles required to implement model based designs.

Traditional design involves multiple phases including modeling and simulation, architectural design, detailed design, and code and unit test. Each phase is further and further removed from the modeling world of the SME who best understand what the system is to accomplish. Changes and improvements to a system require that they first be expressed at the model and simulation level, and then be translated into the multiple phases expressed earlier. These intervening design cycles introduce significant risk that (i) the design intent is lost, (ii) errors are introduced, and (iii) system life-cycle costs increase. At present, this translation is accomplished by a series of independent tools which, first translate Simulink models into C programs, then translate C programs into VHDL, and finally yet other tools translate the VHDL into the final chip layout.

A key problem is each level of processing flattens the upper level architectural entities and replaces them with lower level components. A complex mathematical formula in Simulink may appear as a set of C instructions which in turn appear as a set of VHDL statements which in turn appear as a set of gates which in turn appear as a set of switch settings in an FPGA. When timing, area or power properties of the gates are finally determined it is very difficult to identify the high level Simulink component that is associated with the detailed lower level information.

The goal of this project is to develop a tool which is able to back-annotate the high level constructs with the low level properties thus allowing the SME to optimize the design. Back-annotation is the process of linking lower level data with higher level design entities. The tool must create a meta-model which tracks the linkage between the low level constructs and the high level abstracts.
Prior work in back-annotation has been performed in other, more limited domains. Reference (1) describes a back-annotation system for propagating worst case timing estimates to Matlab/Simulink models. This data, however, is not real information obtained from as-built systems but is rather an estimator. Reference (2) describes back-annotation of post layout delay information into models where the models are graph representations of a computation. These models are substantially lower level than those presented by Simulink models.

Once such a meta-model is developed, it can also provide enhanced capability for the verification and validation of such systems, providing an identifiable linkage between the low level implementations and high level abstractions.

ITAR control is not required. DD Form 254 is not required.

PHASE I: The goal of the Phase I research will be to (i) identify the design entities used in each level of a MBDI environment, (ii) develop a meta-model for each of these entities and a linkage mechanism between them, (iii) demonstrate a meta-model language suitable for representation of the meta-model (for example, UML), and (iv) identify the critical performance parameters that need to be back annotated for design optimization (e.g. timing, power, area, etc.).

The deliverable for the Phase I effort will be a detailed report proposing how to create the meta-models, how to link the models together, and how to provide the information to the SME.

PHASE II: The goal of the Phase II work will be to develop, test and demonstrate the tools for: (i) creating the meta-models, (ii) linking the meta-models to the abstract model at the top and low level models at the bottom, and (iii) to provide back-annotation of performance details at the lower level to the higher level abstract models.

The deliverable for the Phase II effort will be a prototype system that actually creates meta-models of the high level system and cross links these to low level implementation together with low level performance information.

PHASE III: The end state for Phase II will be a working prototype tool for back-annotating high level models with low level performance data such as timing, area and power consumption. Typical military systems to which this tool can be applied are missile guidance/navigation, treat tracking/recognition, radar scene generation, and fire control.

This tool can be used in any commercial activity that pre-supposes a path from modeling and simulation to implementation using a model based design tool such as Simulink. Funding for this effort is expected to be provided for by one or more of the electronic design automation tool vendors such as Mentor Graphics, or one of the modeling tool vendors such as Mathworks.

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KEYWORDS: information systems technology, model-based design and implementation, meta-modeling, back-annotation of performance data.

A09-132 TITLE: Automated Preparation of Geometry Models for Computational Applications

TECHNOLOGY AREAS: Information Systems, 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: Contractor shall develop methods that automatically import, repair, defeature, and construct surface and volume meshes of three-dimensional geometry models for Computational Fluid Dynamics (CFD) and Computational Structural Mechanics (CSM) applications.

DESCRIPTION: It is a well known fact within the Government and commercial sectors of computational science communities that, generally speaking, three-dimensional Computer Aided Design (CAD) geometry models constructed for manufacturing purposes are not directly useable by applications such as computational aerodynamics, Computational Fluid Dynamics (CFD), Computational Structural Mechanics (CSM), computational heat transfer, and computational electro-magnetics solvers. Production level CAD models typically contain thousands of small internal and/or external geometric details that do not add value to the analysis being conducted and which must be removed. In addition, these geometries almost always possess numerous bolt holes and gaps that prevent CAD models from being watertight. Watertightness of components of interest is an essential requirement for them to be useable by computational analysis tools, so these openings have to be sealed. Further, since CAD tools (both commercial and Government) may not import the models geometric entities correctly, additional repairs must be performed. However, after all repairs and defeaturing have been performed, surface and volume meshes must be constructed for direct use by computational applications. Currently, several weeks are needed to perform the typical preparations described above, and this directly reduces the responsiveness and productivity of the computational engineer. It is essential that this process be streamlined so that computational engineers become more productive, responsive to customer requests (such as those posed by the Targets Management Office, the Joint Attack Munition Systems Project Office, the Unmanned Aerial Systems Project Office, and the Missile Defense Agency), and competitive in the global marketplace. Consequently, innovative solutions are requested that automate the geometry model preparation process for computational applications so that the process time is reduced to a few hours. ITAR control is required, but a DD Form 254 is not required.

PHASE I: Contractor shall develop and demonstrate prototype computer software that: (1) imports production level, three-dimensional Computer Aided Design (CAD) geometries in the STEP and Parasolid formats, (2) automatically identifies and repairs geometric entities that get imported incorrectly, (3) allows the user to automatically remove internal or external features while retaining all external or internal features, (4) automatically identifies geometric features, gaps, and holes and allows the user to specify which ones to retain, (5) automatically defeatures geometric items not selected for retention, (6) automatically closes gaps and holes not selected for retention, (7) automatically insures watertightness for the resulting model components, (8) exports the resulting model in file formats that are directly compatible with commonly used grid generation tools, including Cart3D cubes, Gridgen, Pointwise, Chimera Grid Tools, Solidmesh, AFLR, Cubit, and CFD-GEOM, and (9) is cross-platform capable and, at a minimum, directly compatible with the Red Hat Linux Enterprise 5.3 and later operating system as well as the Mac OS 10.5 and later operating system. Required Phase I deliverables will include the developed computer software in source code format, including all makefiles, database files and include files.

PHASE II: Contractor shall develop, demonstrate and validate fully operational computer software that: (1) imports production level, three-dimensional Computer Aided Design (CAD) geometries in all commonly generated formats, including the STEP, Parasolid, IGES, and SAT formats, (2) accomplishes all Phase I objectives, (3) allows the user to easily specify criteria (such as initial point spacing, point distribution functions, number of grid points, domain boundaries, mesh type, and boundary conditions) for use in creating surface and volume meshes on, above and/or within user-selected geometric surfaces and volumes, (4) automatically generates structured (multi-block and overset) surface and volume grids based on the specified criteria, (5) automatically generates unstructured and hybrid (traditional and overset) surface and volume meshes base on the specified criteria, (6) exports the resulting surface and volume meshes in file formats that are directly compatible with commonly used grid generation tools, including Gridgen, Pointwise, Chimera Grid Tools, Solidmesh, AFLR, Cubit, and CFD-GEOM, (7) exports the resulting surface and volume meshes in file formats that are directly compatible with commonly used Computational Fluid Dynamics (CFD) and Computational Structural Mechanics (CSM) analysis codes, including Cart3d, Wind US, Overflow, USM3D, DPLR, FUN3D, ABAQUS, ANSYS, CTH, LS-DYNA, and MSC/NASTRAN, (8) is compatible with both the Plot3D and CGNS file formats which are community standards for data exchange by CFD solvers, and (9) is cross-platform capable and, at a minimum, directly compatible with the Red Hat Linux Enterprise 5.3 and later operating system as well as the Mac OS 10.5 and later operating system. Required Phase II deliverables will include the fully developed computer software in source code format, including all makefiles, database files and include files.

PHASE III: It is expected that all Department of Defense services will be keenly interested in the dramatic reduction in labor time and cost required of computational engineers to prepare CAD geometry files for use by computational applications. Specifically, the Joint Air to Ground Missile (JAGM) program and the Helicopter Area

Protection System (HAPS) in-house technology effort will benefit directly from the increased productivity, throughput, and responsiveness of high-fidelity computational analyses that will be applied to their product development process. Further, it is expected that the military and commercial sectors of the economy will also be greatly interested in the significant streamlining of their product development cycle that will be brought about by the automated geometry preparation tool developed under this SBIR. The drastic reduction in development time and costs of fixed- and rotary-wing aircraft, unmanned spacecraft, engines to propel these vehicles, surface ships, submarines, weapons, passenger aircraft and helicopters, automobiles, manned spacecraft, engines for these vehicles, cooling systems for computers, medical devices such as artificial hearts, and prosthetics will dramatically enhance the global competitiveness of companies that utilize computational analysis tools to make these products. Consequently, the automated geometry preparation tool would be readily marketable to numerous customers via presentations made at various technical conferences, advertisements in trade publications, and direct sales presentations.

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KEYWORDS: Computer-Aided Design, CAD, three-dimensional Geometry, Computational Fluid Dynamics, CFD, Computational Structural Mechanics, CSM, surface meshes, surface grids, volume meshes, volume grids, CAD to grid, geometry conversion, Parasolid, STEP, IGES, SAT, OpenCASCADE, SolidWorks, Cubit, Pro Engineer, Geometry and Grid Toolkit, GGTK.

A09-133 TITLE: Power-On Missile Stage Separation Simulation

TECHNOLOGY AREAS: Information Systems, 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: To develop an advanced physics based simulation capable of capturing the flow physics and dynamics of a hot-fire missile stage separation in flight.

DESCRIPTION: Power-on endoatmospheric multi-body separation is one of the most difficult problems facing the designers of advanced multi-stage missiles. Indeed, power-off endoatmospheric drag separation is often the preferred technique to avoid the introduction of unwanted asymmetric forces in the upper missile stage during the separation event. However, power-off separation is a time consuming event, in comparison to power-on stage separation, which can severely limit the response and lethality envelope particularly for a missile interceptor system. Hence the need for a predictive dynamic hot-fire multi-body separation model and design tool for those missile applications wherein power-off stage separation is not an option. Proper multi-body separation simulations at the dynamic conditions encountered in flight require the coupling of three critical, independent parameters including (1) external flow conditions, (2) upper stage rocket ignition, and (3) the dynamic separation event. Two elements for simulating the dynamic separation event must be implemented. The first element is the dynamic motion of the bodies where each of the stages would be supported with independent 6-degree of freedom (6-DOF) simulation system models. This element would allow for unrestrained motion throughout the transient separation event time. The second element would be the forcing function developed by the propulsion of each stage describing the behavior of the aero-propulsion interaction in the deployment of the second body for a completely unrestrained free-flight separation. Both elements would be simulated during the separation event using the thrust profile for each of the stages and the same range of freestream conditions. The simulation requires a transient description of the propulsion events of each stage as well as the interaction of these propulsive streams with the external free stream flow and the interstage. The ability to simulate unrestrained, hot-fire stage separation systems would greatly enhance the ability to design efficient interceptors and other multi-stage vehicles, as well as helping to define expanded operational ranges for safe/reliable operation of current configurations.

PHASE I: Technical approaches will be formulated in Phase I to provide innovative stage system simulations which describe the transient separation event for a two stage, powered supersonic/hypersonic missile flight at low altitude. To be both practical yet adequate, the simulation of such innovative and improved designs must give special consideration to the following: 1. Flight Mach Number from 3 to 8 2. Flight Altitude from 5 to 15 km 3. Interstage blow-out vents used during the separation event 4. Stages attached for 20 to 200 ms before separation 5. Solid propellant motors used in both stages with metallized propellants (5 to 20 mass percent metal) 6. Missile angle of attack less than 1 degree At least one innovative, meaningful demonstration will be executed and a flow field solution produced with the computational model during Phase I to assess the potential for Phase II success. Such a demonstration could, for example, model the simple case of a power-off endoatmospheric missile stage separation event with asymmetric aerodynamic loading since this methodology would feed directly into the Phase II prototype demonstration.

PHASE II: The physical model formulated in Phase I will be developed and refined using computational fluid dynamics to evaluate stage separation and flight characteristics over a broad range of flight scenarios of interest. Additionally, this advanced computational fluid dynamics model will be run blind for a a hypersonic power-on stage separation test case for which detailed flowfield data will be available to demonstrate the advanced capabilities for analyzing and modeling these events.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be a validated predictive model for the analysis of power-on endoatmospheric missile stage separation events. The transition of this product, a validated research tools, to an operational capability will require additional upgrades of the software tool set for a user-friendly environment along with the concurrent development of application specific data bases to include the required input parameters such as missile geometries, solid rocket motor properties, and performance parameters. For military applications, this technology is directly applicable to all multi-stage rocket propulsion missile systems. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of advanced missile interceptors such as the KEI and SM-3 programs. For commercial applications, this technology is directly applicable to all multi-stage commercial launch systems such as the NASA Aries, and the Delta and Atlas families.

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KEYWORDS: stage separation, solid propellant rocket motors, flight dynamics, missile systems

A09-134 TITLE: Air-Breathing Missile Thrust Measurement

TECHNOLOGY AREAS: Air Platform, 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: To develop the capability to make direct measurements of forces on air-breathing powered vehicles in a shock tunnel at duplicated flight conditions.

DESCRIPTION: It has always been difficult to verify advances in air breathing propulsion technology because of the inherent obstacles to making accurate force measurements. For all air-breathing systems, the net propulsive force of thrust minus drag is the difference between two large numbers leading to poor quality data with considerable uncertainty. Such measurements are difficult enough in direct connect facilities but become almost insurmountable for full up air vehicles at hypersonic speeds in a free-jet shock tunnel environment. Hence, air-breathing propulsion technology advances have been difficult to verify. None-the-less, recent advances in MEMS technology instrumentation provide evidence that on-board interference-free instrumentation could conceptually be employed as a means for accurate force measurements in a shock tunnel. Therefore, innovative techniques for measurement of net thrust for an air-breathing, power-on missile operating in a shock tunnel are sought for a variety of supersonic/hypersonic missile concepts.

PHASE I: Innovative technical approaches will be formulated in Phase-I to make force measurements for a hypersonic air-breathing powered vehicle in a shock tunnel while addressing the key problem areas of (1) short run time of the shock tunnel < 100 ms, (2) vehicle vibrational modes, (3) non-flight weight test articles, (4) high frequency mode filtering, and (5) high longitudinal stability. At least one innovative, meaningful concept will be developed and delivered during Phase-I to assess the potential for Phase-II success. Such a demonstration could, for example, provide for the measure of drag force on a simple inlet in a Government run shock tunnel test.

PHASE II: The force measurement concept formulated in Phase-I will be developed and refined using appropriate instrumentation technology which provides the accuracy required to make direct measurement of air-breathing powered net thrust. This instrumentation package will be developed for a specific shock tunnel and delivered to the Government during Phase-II.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be an instrumentation package for the direct measurement of forces on air-breathing powered vehicles in a shock tunnel at duplicated flight conditions. The transition of this product, a measurement concept, to an operational capability will require demonstration and validation of the instrumentation package. For military applications, this technology is directly applicable to all high speed air-breathing missile systems. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of advanced hypersonic missile systems such as the Navy/DARPA HyFly, Air Force X-51, and DARPA Facet programs. For commercial applications, this technology could transition to thrust measurements for all commercial air-breathing propulsion systems.

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KEYWORDS: force measurement, net thrust, air-breathing propulsion, shock tunnel, MEMS

A09-135 TITLE: Innovative Inertia Devices

TECHNOLOGY AREAS: Electronics, Weapons

OBJECTIVE: Develop low-cost innovative inertia-based components for flight control of high-G gun-fired munitions with the goal of providing very affordable guidance and control systems for future guided munitions. These inertia-based components must be capable of withstanding very high-G firing accelerations from 30,000 Gs to 120,000 Gs, but be sensitive enough to yield the required precision that is needed for flight control purposes. The components must be designed to be scalable across all munitions applications, including large to medium caliber rounds.

DESCRIPTION: The state of the art in shock resistant component design is to reduce the size of the proof mass, thereby reducing the related forces, moments, and torques that are generated as a result of high acceleration levels. Physical stops are also generally provided to limit the maximum proof mass displacement/rotation to prevent damage to the moving components of the inertia component. However, by reducing the size of the proof mass, the sensitivity is degraded, thereby making it insensitive for use for flight control purposes. This is particularly the case for high-G gun-fired munitions applications in which the setback acceleration levels could be up to 120,000 Gs and a sensitivity of a fraction of a G (preferably better than 0.1 G) is sometimes desired. Currently available inertia components also suffer from relatively long settling times following firing. The introduction of MEMS technology in recent years has made it possible to reduce the size of the proof mass significantly, independent of the accelerometer type and their mechanism of operation, but for the present applications, the developed designs have not yet solved high-G survivability, low relative sensitivity and low settling time problems. This proposal should provide very affordable guidance and control systems for future guided muntiions and address the issues of measurement accuracy, sensitivity, required calculations, susceptibility to environmental noise and methods of reducing their effects, optimal design of the proposed sensors through modeling and simulation, and in particular, methods of their manufacture and expected cost when mass produced. The primary trade-off parameters to be considered are cost (order of magnitude less than those of current devices), size (0.5cm or less), power consumption (1 mW or less), accuracy (0.05 g or better) and settling time (3 ms or less).

PHASE I: Develop analytical models to study the feasibility of the proposed concepts and through computer simulation determine their potential performance. For the most promising concepts, develop detailed enough designs and appropriate algorithms for their optimal design. The designs must consider the manufacturing process that could be used for their mass production as low-cost components using existing mass-production technologies.

PHASE II: For the most promising concepts, develop detail designs for selected range of applications. Develop the manufacturing process needed for the fabrication of prototypes of the developed inertia-based components. Fabricate prototype of the inertia-based components, perform laboratory tests to validate and fine tune the developed analytical models and determine the characteristics and performance of the components. Perform instrumented survivability tests with air guns. Make final modifications to the developed designs and fabricate final prototypes for laboratory and air-gun tests, and prepare for firing tests.

PHASE III: The dual use potential of inertia sensors with very fast settling time that are very sensitive while capable of withstanding shock loading and related technologies from this effort are widespread. As is often the case, military requirements exceed those of industry; however, the advances made could result in making sensors in general and MEMS sensors in particular much more suitable for many guidance and control and other similar applications such as UAVs, UGVs, robotic systems, and high-speed and precision production machinery.

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KEYWORDS: Accelerometers, Sensors, Inertial Sensors, Low-Cost Sensors for future Armaments, High-G Sensors, Guidance and Control

A09-136 TITLE: Multispectral Gamma Detector for Explosives Analysis

TECHNOLOGY AREAS: 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: To design, develop, and demonstrate a compact, efficient, and rugged multispectral gamma ray detector, to include electronics and processing software, for use in a Prompt Gamma-ray Neutron Activation Analysis (PGNAA) system for analysis of unexploded ordnance (UXO) and remote detection of land mines and Improvised Explosive Devices (IEDs) in the battlefield.

DESCRIPTION: The detection and identification of explosive devices in the laboratory and in the field is challenging problem. Explosive Ordnance Disposal (EOD) items are brought to QE&SA's Radiographic Laboratory for analysis on a regular basis. Unexploded ordnance (UXO), land mines, and IEDs are found in the field.

Prompt gamma-ray neutron activation analysis has been shown to be an effective tool for detecting and identifying explosives. Refs.(1)(2) It's use, however, has been limited to applications in which the equipment can be placed in close proximity to the explosive. In PGNAA a material is probed by a beam of neutrons from an accelerator source or radioisotope. Neutrons interact with the nuclei of target atoms causing them to emit gamma rays. Explosive compounds have a gamma ray signature, which if it can be measured, can be used to identify the material. The advantage of PGNAA for explosive ordnance detection is that the neutrons readily penetrate earth and steel while also having a high probability of interacting with low-density materials found in explosives. It works by measuring the ratios of the main constituent elements of the most common explosives, carbon, hydrogen, oxygen and nitrogen. However, the method has been used mostly in situations where a (stationary) high-flux neutron source was available, measurement time was not a critical parameter and the sample could be placed close to the source and the gamma detector. By contrast, explosive ordnance detection in the field must be accomplished at a safe standoff distance (10 meters or more) and in near-real-time (less than one minute) for minimum explosives quantities of 10 kg. Consequently, the use of PGNAA for this purpose depends on neutron sources that can provide sufficiently high flux, and on high-efficiency detectors for gamma rays whose energy ranges from 2.2 MeV for hydrogen to 10.8 MeV for nitrogen. Moreover, both these components need to be relatively small, lightweight and rugged enough to be transportable.

For the purpose of this solicitation, the contractor may assume a thermal neutron flux of 10^8 neutrons/cm^2/sec at a distance of 1 meter from the source. Without the thermalizing moderator, the flux may be a factor of 100 to 1000 higher.

This solicitation seeks the development of a compact, highly efficient, multispectral detector for gamma rays in the energy range from approximately 2 MeV to 11 MeV, along with the electronics required to process the detector signals. Energy resolution must be sufficient to identify the relevant gamma emission lines and distinguish them from other nearby lines. Detector solutions allowing the acquisition of additional information that would improve the signal-to-noise ratio and thus enhance the detector sensitivity are actively encouraged. Examples include the ability to identify the direction from which the detected photons originate and correlate it with the direction of the neutron beam used for the activation. The resulting system must be transportable in a military vehicle, such as a Humvee, and must have no unusual power requirements.

PHASE I: Perform research and analysis of a PGNAA detector as described above. Provide proof of concept by development of a preliminary detector design and simulation of its performance, and/or by measuring the response of a small sample detector to photons of several MeV.

PHASE II: Develop and fabricate the prototype detector designed in Phase I. The detector volume should be large enough to meet the requirements outlined above. Tests of the detector will be performed at ARDEC's Radiographic Laboratory, which has the necessary neutron sources and target materials, in order to demonstrate feasibility and provide proof of concept.

PHASE III: End vision: Successful completion of Phase II will demonstrate feasibility of PGNAA to detect explosive ordnance at reasonable distances and within reasonable times. Such a demonstration will enable the contractor to attract an industrial partner for further development and marketing. Military applications include EOD/UXO detection and identification, IED detection, as well as surveillance and reliability assessment of stockpiled weapons. Homeland Security applications would be in the area of containerized cargo screening for concealed explosives. Commercial applications may include ship containers in seaport locations.

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3. SBIR Topic A07-040, High-flux electronically generated thermal neutron source for radiographic applications. Contracts W15QKN-08-C-0515; W15QKN-08-C-0516.

KEYWORDS: neutron activation analysis, prompt gamma neutron activation analysis, prompt gamma-ray activation analysis, NNA, PGNAA, PGAA, Explosive Ordnance Disposal, Unexploded Ordnance, land mine detection, IED detection, explosives detection, UXO, EOD

A09-137 TITLE: Fast-Impulse Solid Fuel Miniature Thruster

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a solid fuel microthruster capable of producing 100-150N thrust amplitude with impulse duration less than 100 sec for application in spin-stabilized projectiles or hypersonic projectiles. This state-of-the-art solid fuel thruster will produce greater thrust force with a reduced duration compared to conventional thrusters.

DESCRIPTION: Actuation technologies are an essential component of in-flight projectile guidance. Specifically, miniature thrusters can be used to either impart forces or to disrupt the drag forces on the projectile. In contrast to drag disruption using movable fins or pins, thruster on-off actuation is not affected by drag forces. In addition, the thrusters have no moving parts. However, conventional chemical thrusters have impulse duration in the range of several milliseconds to several seconds.

This program seeks to develop fast-action solid fuel microthrusters with submillisecond impulse duration, while still achieving total impulse similar to that of conventional chemical thrusters. For example, a microthruster containing ~55mg of high-nitrogen propellant (BTATz) is capable of producing specific impulse of ~10 sec, and a thruster containing ~19mg of CuO/Al nanothermite can produce a specific impulse of ~29sec. In addition, the BTATz propellant thrust is ~40mN and ~400msec in duration, whereas the nanothermite thrust is ~60N and 90 sec in duration. Other types of materials that may be capable of producing short-duration, high-force thrust pulses include energetic materials with high combustion rates.

The thrust requirements depend on the exact system in which the thruster is inserted. The thruster will be developed for either the Excalibur, the Hellfire, or Copperhead. Other general requirements of the developed system is to survive high-G (>10,000 Gs) from setback forces during launch, thermal stability, low ignition sensitivity, and long-term stability.

PHASE I: Identify solid fuel candidate materials and perform initial characterization in a thruster test stand. Application for the solid-fuel thruster will be selected. In addition, design a prototype thruster and outline a plan for integrating the thruster into the desired application system.

PHASE II: Fabricate the prototype thruster designed in Phase I. Determine optimum operation from candidate materials identified in Phase I. The solid fuel will be further studied for performance and sensitivity, and formulation will be fine tuned to meet sensitivity requirements. By the end of Phase II, the prototype will be ready for wind-tunnel testing in simulations of the application system.

Phase III: Strategic partnerships will be developed to further the commercialization potential of the technology. Commercial applications include guidance for small air vehicles and for satellites. Specifically, this technology would be well suited to controlling the altitude and the trajectory of orbiting satellites. Growing numbers of commercial satellites in orbit require course adjustment at high velocities to avoid other satellites and debris orbiting the earth. Another commercial application is tailored compact airbags for personal protection. Military applications include large caliber munitions, missiles, and futuristic small caliber weapon systems.

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3. R. Barrett, G. Lee, Guided Bullets: A Decade Of Enabling Adaptive Materials R&D, 24th Army Sciences Conference, 29 Nov. - 2 December 2004, Orlando, FL

KEYWORDS: Micropropulsion, guidance, nanothermites, projectile, thrust, specific impulse

A09-138 TITLE: Multi-Threaded Missions and Means Framework

TECHNOLOGY AREAS: Information Systems, Weapons

OBJECTIVE: To explore the utilization of a modeling and simulation environment where multiple military domains or threads (e.g. Logistics, Transportation, Combat Operations, Intelligence, Engineering) can be described in terms of tasking and capabilities and their mission interactions simulated over some mission scenario time horizon. The effort will explore extending the Missions and Means Framework (MMF)(See Reference 1) from a single military thread application, combat operations, to a multi-threaded MMF that can be applied to two or more operational thread interactions. Utilization of autonomous agent technology will be explored for use in the simulation environment to represent the military decision making process that will create interactions that create courses of action due to changes in one or more defined state variables representing operational knowledge elements. A multi-threaded MMF capability will allow the examination of MMF level 1 battlefield interactions between two or more military threads by utilizing autonomous agent technology in a simulation environment (See Reference 2) for the express purpose of conducting experimentations that represent military decision making with sufficient accuracy to identify those knowledge elements that are critical to taking preemptive course of action that prevent mission failure. This effort will provide the Army with the capability thru modeling and simulation to identify knowledge and information elements that are critical to decision making that directly impacts operational mission outcomes success or failure. Knowledge and information are the key components to the human dimension side of the Common Operating Picture. The ability to identify such knowledge elements will serve as the foundation for the development of advanced future force predictive analyses tools, decision making models, and provide the building blocks for sustainment modeling and simulation training systems that will be needed by the future force to allow sustainment decision makers to better understand what information is critical and what the impact and ripple effects are of those decisions over mission time on overall mission success.

DESCRIPTION: The Missions and Means Framework (MMF) is a methodology for explicitly specifying a military mission and for quantitatively evaluating the mission utility of alternative warfighting DOTMLPF (See Reference 3) services/products. To date, the MMF has been used to examine and develop combat operation models that examine the matching of military tasks associated with the combat operations in question with the military means needed to successfully achieve those objectives. As a result, the natural application of MMF has been within the context of Blue Force versus Red Force combat operation models. For a military operational thread to execute successfully, it often must interact with other military operational threads that provide essential capabilities required at specific times. For example, the logistical operations must plan and execute sustainment deliveries to combat operations forces for mission success to occur. The extended MMF capabilities will provide the capability to describe and characterize the complex top-down planning process as well as the bottom-up employment process to execute and assess the complex dynamic interactions of all these military operational threads. Through the development of a prototype modeling and simulation capability using autonomous agent technology, MMF level 1 thread interaction effects can be simulated for a hypothetical mission and mission time horizon involving two or more distinct operational threads with the objective of determining favorable or unfavorable outcomes. Unfavorable outcomes at the interaction level can be traced back to material and/or personnel state changes up to specific tasks and/or capabilities that lead to an unfavorable interaction (i.e. mission failure). These state variables represent the knowledge and information elements and allow are critical to mission success for a given hypothetical mission.

PHASE I: Research and investigate the Missions and Means Framework. Develop constructs and extents to MMF to support a multi-threaded MMF. Research and identify suitable autonomous agent based simulation technology where autonomous agents have sufficient descriptive metrics to serve as potential simulation platform to demonstrate level 1 multi-threaded MMF interactions. Develop a two threaded MMF description between the logistics thread and combat operation thread to demonstrate the capability of the approach being developed is able to describe and characterize the complex top-down planning process as well as the bottom-up employment process to execute and assess the complex dynamic interaction between the two threads.

PHASE II: Fully develop the constructs and extents to MMF to support a multi-threaded MMF bottom-up assessment of interactions between the operational domains of Combat Operations, Logistics, Transportation, Intelligence, and Engineering. Research, identify, and develop the descriptive metrics required by the autonomous agents to support a demonstration of level 1 thread interactions in a multi-threaded MMF hypothetical mission scenario. Demonstrate level 1 thread interactions between combat operations and logistics in a simulated hypothetical mission over some mission time horizon.   Further develop and demonstrate that level 1 interactions can be described and simulated in a hypothetical mission for all the threads described in the objective section above.

PHASE III: Pursue defense, public sector, and private sector opportunities to harden and fully commercialize the chosen technologies/concepts.
Commercialization Potential Statement: The multi-threaded MMF methodology could be applied to the analysis of a number of other government and private sector domains where the mission involves complex tasks and timely material means to meet objectives. For example, multi-threaded MMF methodology could be applied to the analysis of natural disaster scenarios (e.g., Hurricane Katrina in the U.S., Cyclone Nargis in Myanmar) via simulation of various interacting civil management threads such as sustainment, medical relief, reconstruction, and law enforcement. Another example would be to apply multi-threaded MMF methodology to the analysis of large scale construction projects where simulation of various interacting contractor and supplier threads such as heavy equipment, concrete engineers, labor, and supply companies must occur in a timely manner to meet time & cost construction objectives.

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KEYWORDS: Missions and Means Framework, autonomous agents, simulation, logistics, sustainment

A09-139 TITLE: Capacitor thermal management for mobile power electronics

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

OBJECTIVE: To develop compact, low thermal resistance solutions for maintaining the temperature of non-planar, film capacitor arrays. Better temperature control in vehicular systems will reduce the need to de-rate components, improving reliability and system energy density.

DESCRIPTION: Future military platforms, including Armys FCS MGV, Air Forces MEA, and the Navys DDX ships will require more extensive use of electronic power conditioning systems to achieve required performance levels. Proper thermal management of these high power electronic systems becomes more difficult as increasing power density requirements push heat generating components closer together. Film capacitor arrays can make up a large volume of these systems, and on vehicles their relatively low full power operating temperature limits (in the range of 60-90C) often force designers to de-rate the components to ensure reliable operation. The combination of close proximity to hot components, volumetric self-heating within the capacitors, and platform coolant temperatures as high as 80-110C all contribute to increased system volume from redundant capacitors arrays operating with reduced energy density. While ongoing research efforts are attempting to develop capacitor materials with higher operating temperature limits, improved methods of efficiently managing capacitor bank temperature would provide near-term reduction in the need for component de-rating which would reduce component redundancy and increase system power density.

Most high-energy film capacitors with a cylindrical, can-style structure cannot efficiently couple to the high performance cold plates and heat sinks being implemented to cool other power electronics components. Although air-cooling methods (including finned adapters, etc.) have been utilized in the past, system volume constraints and platform placement typically remove useful convective flow paths. Other proposed techniques for thermal coupling have included the use of inefficient thermal interface materials, thermal conduction through the electrical terminals, or significant modification of the capacitor structure, none of which provide a cost and performance effective solution.

This SBIR seeks to identify novel high performance capacitor thermal management solutions for military vehicle power electronics systems to reduce the need for de-rating and redundancy. These systems typically utilize sizeable arrays of standard commercial capacitors (45cm3 capacitor, 250 microfarad array, 900V rating), are cooled by a heatsink operating at minimum of 80C, and the array is in close proximity to 150C switch components. As much as 10 degrees C of self heating of the array can result depending on operating frequency. The ability to efficiently couple a standard capacitor to the systems copper or aluminum cold plate while minimizing additional volume requirement would significant benefit to future military capability.

PHASE I: Investigate novel compact cooling mechanisms compatible with standard film capacitor technology that would enable effective coupling to a systems copper or aluminum cold plate. Use modeling and/or experiment to evaluate thermal performance in comparison with standard cooling methods mentioned above. Design details for scalability to larger capacitor arrays, and impacts of the solution on assembly difficulty and capacitor or array line replacability should be addressed

PHASE II: Demonstrate a prototype capacitor array cooling scheme in a surrogate system environment using the concept developed in Phase 1. Evaluate the performance and limitations of the prototype for a range of coolant temperatures and internal/external thermal conditions. Validate through modeling or demonstration the ability to transition the solution for specific military applications and characterize any array dependent size/performance trade-offs inherent in the solution.

PHASE III: Design and develop a modular capacitor cooling mechanism for a particular military application, meeting appropriate MIL-SPEC operational requirements. Continued commercial investment in hybrid ground and air vehicles will increase the demand for larger power conversion systems. A scalable, cost-effective capacitor cooling scheme will enable lighter, more compact electronics solutions to reach the commercial market.

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KEYWORDS: thermal management, capacitor, cooling, power electronics

A09-140 TITLE: <u>Ballistic Shock Mitigation Materials and Technology for protective system</u>

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: The overall objective of this proposed program is to develop a bio-inspired shock mitigation material system concept that attenuates the ballistic shock response to an industry standard tolerance level. The proposed system should be capable of mitigating high frequency shocks that is detrimental for equipment survivability and reducing low frequency load transmission that is fatal to human safety in a demanding high-g environment (MIL-STD-810F) (3). The technology will address the increasing demand of protecting occupants in advanced armored vehicles or electronics equipment in the next generation smart munitions and guided projectiles.

Specifically, the focus of this SBIR is to:
a. Develop computational models to capture the ballistic response-mitigation behavior on bio-inspired cellular or hierarchical micro-structures and such and demonstrate the models capability in predicting and verifying the ballistic response of commonly available Commercial off-the-shelf (COTS) rate-sensitive foam (1) and metallic cellular foam structures (2) for the standard military ballistic shock environment (MIL-STD-810F).

b. Establish the material properties that describe the shock wave attenuating characteristics and quantify the mitigation of ballistic shock response on the bio-inspired structures such as Functionally-graded Materials (FGMs) and hierarchical micro-structures and such.

c. Establish design parameters for candidate innovative bio-inspired based armor protective systems and shock attenuating materials that protect advanced military hardware/occupant against ballistic impacts due to detrimental shock or load transmission.

d. Develop and demonstrate innovative bio-inspired based armor protective systems and shock attenuating materials that protect advanced military hardware/occupant against ballistic impacts due to detrimental shock or load transmission.

DESCRIPTION: There is an increasing need to better protect vehicles, buildings, critical microelectronics components, and especially personnel in severe high-g environments associated with ballistic impact [4]. In particular, advanced characterization and modeling of ballistic impact responses are desired to better understand the physics of shock mitigation and to design new protection concepts [5]. For example, severe transient shock from ballistic impact can incapacitate the functional capability of occupant and/or sensitive sensors, and instrumentation, if they are not properly attenuated by appropriate armor protection systems. This proposal seeks an innovative solution to develop armor protective systems and shock attenuating materials to protect occupant and sensitive equipment against ballistic impact.

The protection level for an occupant of a vehicle in a mine blast, for example, require a limiting force transmission as such the injury level remains an acceptable threshold value (6).   Additionally, computational efforts to mitigate shock waves due to ballistic impact and the experiments needed to support them are sought. Enhancement of armor systems using bio-inspired materials, stronger and more energy absorbent fibers, harder ceramics, and lighter metals are possibilities (7). The enhancement in material performance such as low transmissibility of load or shock response is desired to limit dynamic load transmission to occupant to an acceptable level (6) or to retain functionality of sensitive equipment in a severe ballistic engagement.

With the advent of nanotechnology, it is now possible to engineer materials or craft a system at the smallest length scales to meet the increasingly harsh design environment on Military apparatus [8] . Bio-inspired material system seems to provide such a promising avenue to explore the possibility of developing advanced engineering materials and system for future military applications [9]. Synthetic materials inspired by biological materials evolution have the potential to develop theories to support new material such as cellular foam, artificial silk. Synthetic structures achieve spatial variations in functionality by assembling components made of homogeneous materials (e.g., sandwich panels). Bioinspired products can exhibit improved functionality and simplified assembly using graded materials (e.g., Japanese swords). Therefore, two such materials are worthy of considerations for future Military applications are:
i. Functionally Graded Materials (FGM) with optimal performance when functional requirements vary with location.

ii. Bioinspired Synthetic Materials such as Nickel foam that includes Hierarchical and cellular structure for Armor applications.

This proposal seeks to employ biologically derived materials for improved warfighting effectiveness that impact the enhancement of protection against ballistic impact and to develop an integrated experimental and computational tool to support design development of such future shock attenuating materials for Military applications.

PHASE I: In phase 1, develop an integrated experimental and computational tool to support the design development of armor protective systems for ballistic impact. This phase would require accomplishing:

- Identify or develop computational models to derive the ballistic shock wave attenuating characteristics of the bio-inspired structures such as FGM and hierarchical micro-structures and such.

- Develop experimental procedures to derive dynamic properties needed to describe the computational model for bio-inspired structures such as FGM and hierarchical microstructures.

- Initiate experimental verification of Computational Model and Shock Loading Response propagation mechanism of commonly available COTS rate-sensitive foam (1) and metallic cellular foam structures (2) for the standard military ballistic shock environment (MIL-STD-810F).

PHASE II: Develop and engineer innovative bio-inspired based armor protective systems and shock attenuating materials that protect advanced military hardware/occupant against ballistic impacts due to detrimental shock or load transmission in a realistic environment. Conduct testing to prove feasibility over extended operating conditions and demonstrate its effectiveness in shock mitigation over existing systems.

- Develop ballistic shock Modeling Principles for Bio-inspired Structures and set trends that govern the design performance of the candidate materials at full scale and lab scale.

- Characterize Shock Loading Response of Bio-inspired Structures at Lab Scale, establish design parameters that optimize the ballistic response of bio-inspired system and determine trends.

- Quantify the mitigation of ballistic shock response on the bio-inspired structures such as FGM and hierarchical micro-structures and such.

- Develop biologically inspired candidate armor protective systems, verify and demonstrate their performance in small scale lab tests.

PHASE III: This phase will focus on full-scale validation and verification of the proposed innovative bio-inspired engineered systems for added protection again severe ballistic loads.

This system could be used in a broad range of military and civilian applications where protection against severe shock due to ballistic impact are necessary, for example, protection of electronic equipment in advanced military applications or enhancing safety and functionality of civilian equipment in a shock environment.

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KEYWORDS: ballistic impact, shock mitigation, armor materials, protective system, computational mechanics, bio-inspired materials

A09-141 TITLE: Mitigating Optical Turbulence using a Real-time Image Restoration Processor

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop an inexpensive optical turbulence video restoration system capable of correcting distorted visible and IR imagery in real-time that is often associated with long-range viewing, i.e., in excess of 1km.

DESCRIPTION: The amount of information conveyed by a highly magnified image of a distant object is often limited by adverse atmospheric conditions that serve to reduce both spatial resolution and image contrast. This is particularly true for optical paths close to the ground where refractive turbulence and light scattering due to haze is most severe. Although atmospheric aberrations effect all light either reflected or emitted, it is especially troublesome in the IR. Advanced IR imaging systems currently under development will not be limited by sensor characteristics, but by atmospheric degradation. It will be necessary to restore the original information content of the imagery to take full advantage of these next-generation sensors. Various post-processing algorithms are needed that are capable of restoring atmospheric degraded imagery. As an example, one such technique is based on a linear systems approach in which a predetermined atmospheric modulation transfer function (AMTF) is deconvolved, resulting in an enhanced seeing ability.[1-12] Currently, there is a great deal of debate within the scientific community on which post-processing algorithm is of greatest value. In order to resolve this important issue, the authors would like prospective candidates to propose an optimal post-processing algorithm designed to mitigate atmospheric effects (based on cited research) and to develop a unique programmable video processing device that could be used to implement the necessary image restoration.

The proposed restoration system should have the following features; 1) be capable of restoring degraded video imagery in real/pseudo-real time, 2) the device should be compact and relatively inexpensive to manufacture, 3) process both analog or digital video signals, 4) incorporate a reasonable amount of adaptability needed to process a variety of standard video formats and resolutions, and 5) the device should be easy to incorporate into existing visible and IR imaging systems, e.g., simply connect in-line between the video-out of the imager and the video-in of the display.
The development of such a device should greatly improve the ability to resolve distant objects when viewed through the atmosphere and would likely represent a welcomed enhancement for both military and civilian applications. Such applications might include, but are not limited to, remote sensing, surveillance/security observations, search and rescue operations, and conventional recreational videotography.

PHASE I: Propose and design the video restoration processing systems including schematics that fully describe and identify all computer processing hardware/circuits/boards used for both mathematical computations and analog-to-digital conversion. Included should be a reasonable prediction of the anticipated performance characteristics of the device. The development of a prototype is desirable.

PHASE II: Assemble, test, and demonstrate a prototype device. An evaluation procedure will be conducted using a variety of degraded video imagery recorded with varying degrees of optical turbulence. Included in the evaluation process will be the creation of objective figures-of-merit that can accurately assess the utility and benefit of the proposed device.

PHASE III: Demonstration/evaluation of the final product will take place at an appropriate U.S. Army field test facility, and will include integration of the device with a third generation FLIR system currently under development. This device will be directly applicable to any long-range imaging system, e.g., visible, infrared, and millimeter-wave. Applications of this technology are numerous and include high resolution remote sensing, commercial videotography, long-range surveillance along boarder regions, and environmental monitoring of remote locations.

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KEYWORDS: optical turbulence, image processing, video processing, image enhancement, visible imagery, IR imagery, target acquisition

A09-142 TITLE: Realistic Communications Effects for Evaluation of Tactical Command and Control and Situational Awareness applications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this highly specialized effort is to research, develop, and integrate consistent, measurable interfaces of live radios, networks, waveforms and network managers with high resolution shared code and behavioral models into the OTC simulation and modeling of battle command network integration and simulation (BCNIS). OTCs BCNIS program will provide realistic situational awareness (SA) and command and control (C2) tactical environment for supporting operational testing, without the costs and constraints of deploying a large number of units to the field. OTC will leverage a variety of battle command system simulations and network loading tools to create the appropriate voice, video, and tactical message loads on networks. Additionally, it will be interoperable with other simulations, data collection, and test control tools within the OTC Advanced Simulation and Instrumentation Systems (OASIS) to provide proven systems and network test support. It will support testing in a distributed environment; be compliant with standard architecture, such as HLA and TENA; employ DoDAF architecture views to support development and integration; compliant with DIACAP and Security requirements; and meet V&V requirements anticipated for use in both tactical communications (such as Joint Tactical Radio System) and network-centric (such as the Future Combat System) test programs. OTC will serve as the systems integration lead for BCNIS, as it does for OASIS, but employs technical expertise from across the Army and DoD to leverage and evolve test support technologies. Data collection, reduction, analysis, and visualization capabilities must be able to track and display, in real-time and for post-event analysis: 1) the status of networks and communications devices (performance, location, key settings, quality of service), 2) inputs and changes to network management systems, 3) changes to the routing and delivery of tactical information, and 4) impacted areas and operations. A particular area of focus must be the representation of built environments - especially large urban concentrations and their impacts on communications and tactical information operations (interference, impact of electromagnetic environments, impact of building materials, etc.).

DESCRIPTION: This effort will perform R&D on live radios, networks, waveforms and network managers with high resolution shared code and behavioral models to integrate OTC simulation and modeling BCNIS. Data collection, reduction, analysis, and visualization capabilities must be able to track and display, in real-time and for post-event analysis: 1) the status of networks and communications devices (performance, location, key settings, quality of service), 2) inputs and changes to network management systems, 3) changes to the routing and delivery of tactical information, and 4) impacted areas and operations. A particular area of focus must be the representation of built environments - especially large urban concentrations and their impacts on communications and tactical information operations (interference, impact of electromagnetic environments, impact of building materials, etc.).

Several acquisition programs as well as the test and evaluation community are providing increased focus on the development or integration of capabilities to replicate tactical and operational networks and the communications effects of electromagnetic, weather, terrain, and information operations. These capabilities primarily involve large-scale simulations of communications systems and networks, communications effects servers to provide high resolution modeling of impacts to quality and speed of service, and interfaces and integration methods that link live networks and applications (battle command systems, intelligence fusion systems, and logistics systems) with the simulated network. It is anticipated that within the next few years, evaluators will be able to employ these simulations and interfaces routinely.

A significant gap in most of these efforts is the ability of evaluators to monitor the complex interactions and activities of these hybrid live and simulated networks as they operate in real-time or to understand activities that occurred on those hybrid networks during post-event analysis. For example, one of the first test events projected to use enhanced communications simulations capabilities will occur in the FY2011 time-frame and will employ a simulation of approximately 2000 radios to complement testing of between 65 to 100 real radios in order to replicate large-scale tactical operations. Good progress is being made on evolution of the network simulations and the interfaces between those simulations and tactical applications but little or no real progress is being made that will allow the test officer to monitor during test operations the status of the entire hybrid network live and simulated to assess if the principles of mobile ad hoc networking (MANET) are achieved. The test officer must be able to see communications regions forming and re-forming as the tactical situation changes and must be able to see the impacts on the routing of tactical information.

Evaluators must be able to understand the dynamics of network operations and the impacts on the ability to conduct tactical operations. During post-event analysis, the analyst will want to assess network performance from a wide range of aspects from purely technical (speed and quality of service, network throughput, timeliness of network transformation) to purely operational (what were the impacts on command and control decisions, were fire missions timely if fire support messages were re-routed due to network turbulence, was situational awareness adversely impacted). In either case, the information required is exponentially more complex than that normally provided or assessed during traditional acquisition efforts.

It is envisioned that tools from commercial large-scale network operations (such as cellular telephone providers) may provide some of the potential solutions. Other potential sources of solutions may come from the rapidly evolving field of visual analysis still largely an academic endeavor but showing great promise for net-centric systems analysis and from previous government testing of communications and network systems. Applications for monitoring and analysis would have to integrate with a variety of simulations, application interfaces and data collection instrumentation to perform these functions. The army is adopting commercial standards in battlefield operations. This effort will involve wireless networks that parallel commercial applications in the monitoring of the flow of information in real time battlefield operations.

The goal of this effort is to develop the capability for simulating communications effects via modeling and more importantly, being able to document, understand, and visualize the impact of those effects - by replicating the effects of man-made environments, electromagnetic, weather, terrain, and information operations on tactical and operational network communications. This capability will involve interfacing and integrating live networks and applications with simulated networks to enhance evaluation of communication systems, network waveforms and management systems, and situational awareness and command and control applications.

The Electronic Proving Ground (EPG) and the Communications-Electronics, Research, Development and Engineering Center (CERDEC) are supporting engineering efforts in this effort with OTC and Battle Lab (BL)-Gordon to guide integration and requirements. The modern wireless telecommunications industry that resulted in the development of new services and applications based on new and emerging technology. The influence of the cellular industry has expanded the opportunities within the tactical command and control environment for realistic communications effects to be employed where simulations are developed. Future communications paths are also expected to set the context for expanded wireless technology and more realistic communications effects in simulations within the army.

PHASE I: Perform R&D to determine the feasibility of interfacing and integrating live networks and applications with simulated communications systems and networks, communications effects servers and high resolution models. This study will include identification of performance goals, software specifications, and interface and integration methods required to link live networks and applications with simulated networks and models. The model and stimulation methodology developed must demonstrate the capabilities to simulate communications systems and networks, communications effects servers, and high resolution models with live networks. This must be demonstrated sufficiently to allow on-going development and transition to commercial applications. New and innovative modeling will better allow for testing to replicate tactical and operational networks and the communications effects of electromagnetic, weather, terrain, and information operations to be developed to support operational testing.

PHASE II: The goal of phase II is to develop the prototype and demonstrate the capabilities to simulate communications systems and networks, communications effects servers, high resolution models and integration with live networks. During this phase these dynamics will be demonstrated adequately to allow on-going development and transition to commercial applications to continue.

PHASE III: The capability developed under this SBIR has the potential to meet a wide variety of Government and commercial needs. Potential applications will include the ability to evaluate the performance of large scale networks prior to deployment and fielding, assess the impact of network changes and loading on network performance, and train network users and evaluate systems under a variety of realistic conditions.

The initial customer for this capability will be the Army Operational Test Command (OTC). OTC will utilize the capability to test and evaluate a number Army communications systems and networks.

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http://www.sisostds.org/webletter/siso/iss_104/art_600.htm

3. OASIS:
http://oai.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA491275
http://www.peostri.army.mil/PRODUCTS/OASISEIS/

4. OneSAF:
http://www.peostri.army.mil/PRODUCTS/ONESAF/

KEYWORDS: Communications Effects, Command, Control, Situational Awareness

A09-143 TITLE: Inertially Stabilized Smart Camera

TECHNOLOGY AREAS: Information Systems, 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 develop an inertially stabilized smart-camera (ISSC) that achieves sub-milliradian level image stabilization based on sensing and correcting inertial motion of a camera in the presence of tens to hundreds of milliradian levels of camera vibration over a broad frequency band (1-100 Hz). The ISSC measures and corrects for local vibration-induced angular motion of the field of view independent of apparent motion of the observed target or scene, particularly for low-light fast-frame rate color imaging applications.

DESCRIPTION: Increasingly, digital cameras are envisioned or deployed on unmanned vehicles and at remote stations for long-standoff surveillance and reconnaissance applications. The images acquired by these cameras are subject to apparent motion of the field of view due to vibration of the camera as well as motion and distortion due to atmospheric effects. For many applications, stabilization of the image is highly desirable prior to transmission from the camera to an observer.

Image stabilization can be achieved to varying degrees by a multitude of methodologies, some of which have found success within the commercial still and video camera industry. Mechanical image stabilization actuates the imager in order to suppress jitter present on the observers platform from inducing blurring or perceived motion within the image. Digital image stabilization techniques shift the image data spatially within the output array to compensate for apparent motion of the field of view. These digital methods typically employ scene based approaches to deduce own motion and have demonstrated sub-pixel levels of jitter-rejection given a scene with stationary segments that can be tracked and registered. These scene conditions cannot always be guaranteed under poor visibility or low-light scenarios or when the scene is dominated by moving objects. As a result, scene-based stabilization approaches are explicitly excluded in this topic. Instead, the preferred solution equips the camera itself with instrumentation to sense its own motion and stabilize (either digitally or mechanically) the image before transmission to the observer.

Both Feeback Inertial Image Stabilzation and Feedback Inertial Image Stabilization are established approaches to inertial camera stabilization. However, this topic seeks innovative solutions that push beyond existing performance limits and achieve new levels of stabilization performance required by long-standoff observation systems. Long standoff distances (multiple kilometer paths) and narrow fields of view will entail sub milliradian (10s of microradian) levels of stabilization. This is in the presence of 10 - 100 milliradian levels of local vibrational motion of the camera over frequencies from 1 to 100 Hz. The levels of motion and desired stabilization motivate new approaches to inertial sensing and corresponding advances in embedded processing to digitally correct for measured motion.

At the same time, new levels of smart camera integration are required to seamlessly incorporate the desired image stabilization into fast-framing low-light applications. The camera must be smart to enable easy integration into existing video surveillance applications. All processing must be local within the camera device, without imposing external computational or infrastructure requirements. Typical applications could involve mounting the camera on an unmanned ground vehicle or on a surveillance tower. The camera must be capable of providing better than VGA levels of resolution at greater than 60 frames per second. The ability to provide color images in low-light (sub milli-LUX) is critical to a variety of surveillance missions for discrimination of objects under difficult observational conditions. It would be highly desirable to integrate the image stabilization into an embedded processing capability that is scalable and reconfigurable in order to accommodate additional image processing algorithms for object discrimination and image compression. However, the development and implementation of these algorithms is not the intended focus of this topic.

Key Performance Parameters		
	Threshold	Objective
Stabilization performance (1 – 100Hz rms)	≤ 1 milliradian	≤ 0.01 milliradian
Motion environment (1 – 100Hz rms)	≥ 10 milliradian	≥ 100 milliradian
Minimum Illumination	≤1 milli-LUX	≤ 0.05 milli-LUX
Frame rate	≥ 60 fps	≥ 100 fps

PHASE I: Conduct an initial design and feasibility study on camera, embedded computation, and inertial stabilization technology suitable for meeting the imaging requirements. Any hardware-based proof-of-concept demonstrations during this phase will be viewed favorably.

PHASE II: Build a prototype inertially stabilized smart-camera (ISSC) system which operates in the prescribed T 1 milli-LUX at a d 60 Hz frame rate. Perform a demonstration which compares scene-based with inertial-based image stabilization in the presence of 10 - 100 milliradian levels of local vibrational motion. Estimates for Phase III pre-production costs and suggested revisions to the design (based on test results) will be produced.

PHASE III: The Inertially Stabilized Smart-Camera (ISSC) offers the potential to meet a wide variety of DoD and homeland security needs and as such the commercialization of this prototype into a TRL 7 pre-production unit will be supported in this phase of development.

The customer for the initial ISSC capability is the White Sands Missile Range (WSMR). WSMR will utilize and test the system in support of a variety of active missions. WSMR will request on-going program funding in the Army's Development Test Command (DTC) Technology Development and Acquisition Program (TDAP) system to implement the ISSC capability.

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5. Scott W. Teare; Sergio R. Restaino, Introduction to Image Stabilization, SPIE Tutorial Texts in Optical Engineering Vol. TT73

6. PTU-DISM - Inertial Stabilization Module - www.dperception.com/products_family_advanced-features-ism.html

7. A09-143 Key Performance Parameters

8. Additional information from TPOC in response to FAQs; 48 sets of Q&A posted 08-24-09.

KEYWORDS: Inertial sensors, Electronics, Imaging

A09-144 TITLE: Microfabricated Mass Spectrometer for Near Real-Time Toxic Chemical Detection

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

OBJECTIVE: Develop a microfabricated mass spectrometer (MS) for use in (1) determining permeation rates through personal protective garments and gear and for (2) hand-portable field detection of toxic volatile and semi-volatile organic chemical threats.

DESCRIPTION: This Small Business Innovation Research (SBIR) project is aimed at a creative novel approach to develop a small mass spectrometer (MS) based on microfabrication techniques. There is a need to develop an MS that can be easily and widely applied to unique chemical detection problems, such as swatch testing and field operations. Such a system must be small, inexpensive, robust, and high performing. In order to provide these desirable characteristics, the fabrication methods for the MS analyzer must be simple, highly precise, and low cost. Planar microfabrication techniques offer the potential for satisfying this need.

Development and miniaturization of integrated circuits for advanced computation was one of the most significant scientific advances of all time. There are three fundamental design objectives that guided this advance (reference 1): (1) use thin film processes; (2) keep active components like transistors on one level, at the surface of the substrate; and (3) use the most robust material system available. Analytical chemical instrumentation has benefitted greatly by this advance, mostly at the electronic and computer component level. Additional advanced capabilities are possible by using this approach to design and fabricate the measurement components of analytical instrumentation, and the trend has begun by developments in microfluidics such as microchip capillary electrophoresis, microchip gas chromatography, and microchip liquid chromatography (reference 2). Preliminary efforts in microfabrication of MS analyzers have recently been reported, however, significant innovation and effort is needed for these analyzers to reach their future potential (reference 3). By using microfabrication techniques, it should be possible to design a miniature MS which would operate in the tandem MS (MS/MS) mode in a single device and operate at higher pressures than possible in larger mass spectrometers. Since fouling of electrodes with use is common to all MS designs, and usually determines the frequency of service, the development of throw-away analyzers, which is not unreasonable when based on microfabrication, is extremely attractive.

There are many applications in which instrument size is critical. Obviously, small size is critical for portability, but it is also important when instrumentation must be operated in confined spaces, such as in hoods, and when multiple instruments must be stacked for parallel operation. Furthermore, certain stationary operations require frequent movement of the equipment from one area to another for interval testing. All of these applications could benefit from a new MS analyzer design that is small and inexpensive to fabricate, robust during movement, and easy to remove for servicing and replacement, while still maintaining excellent MS and MS/MS performance. New microfabrication technology should minimize adsorptive surfaces to which analytes could be exposed, greatly reducing the chance for ion-molecule reactions and lengthening the time between cleanings when used as a detector in test equipment, such as the Swatch, Emergency Responder Toxic Industrial Chemicals (ERTIC), Mask, and Glove & Boot test fixtures and when used for detection of chemical threats in the field.

This SBIR topic seeks a novel MS design based on microfabrication techniques to produce an inexpensive, but high performance mass analyzer. The technology should provide simpler, less labor-intensive requirements for cleaning and parts replacement, leading to significantly reduced costs. While feasible, there is significant risk involved in developing a high performance microfabricated MS analyzer. The electrical fields for ion manipulation (e.g., trapping, focusing, and scanning) must be carefully designed and implemented; electrical shielding is especially important for miniaturize analyzers. Materials that are robust under continuous use for extended periods of time must be selected for use as substrates and coatings for patterning of thin-film electrodes and feed-throughs. Novel approaches for ionizing samples and detecting ions with high efficiency are also needed. In addition, low power consumption is critical for field operations.

PHASE I: Perform a feasibility study to develop and demonstrate key performance features of novel microfabricated MS instrumentation for accurate, real-time (or near real-time) detection and identification of volatile and semi-volatile toxic organic chemicals in swatch test fixtures. Generate a detailed design of the new MS utilizing microfabrication methods. Report study findings which will include feasibilities of performance features, detailed design, and microfabrication methods.

PHASE II: Construct a microfabricated MS prototype as designed in Phase I and demonstrate its applicability for detecting target analytes according to the specifications outlined in this topic description. The new MS prototype should demonstrate detection limits better than 100 pg (S/N = 3), and be able to continuously monitor from 0.4 mg/m3 to 200 mg/m3 (direct without split) of target analytes in an air stream. The new MS prototype should also be capable of monitoring an air stream in real-time. This sensitivity and unit mass resolution up to 450 m/z should be maintained for at least 1000 hours of continuous operation.

PHASE III: Deliver a working system to DPG for testing on Swatch, ERTIC, Mask, and Glove & Boot test fixtures. Assist in integrating the new MS in Swatch, ERTIC, Mask, and Glove & Boot fixtures for determining permeation rates of toxic chemical threats. Furthermore, demonstrate the application of the new MS in a hand-portable system for field detection of chemical threats. Provide training for personnel in both application areas.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Private sector applications of the developed technology include (1) use for stationary or mobile routine monitoring of workplace and field environments and (2) use by first responders for field detection of toxic chemicals, solvents involved in arson, drugs of abuse, and explosives, as well as detection of volatile and semi-volatile chemicals associated with agricultural, food quality, biomedical, and environmental issues.

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KEYWORDS: mass spectrometry; microfabrication; detection; chemical threats; toxic industrial chemicals; personal protective equipment; air

A09-145 TITLE: Advanced Readout Development for High Performance Corrugated Quantum Well Infrared Photoconductors Technology

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: Research, design and develop a readout integrated circuit (ROIC) concept that is optimized for high performance C-QWIP (corrugated quantum well infrared photoconductors) detector technology. CQWIP IR technology has not advanced to its potential due to a lack of available low noise ROICs. The readout will be required to be large format (~2Kx2K), small pixel pitch (~15um) and will need to exhibit high injection efficiency, low noise, low power dissipation, high dynamic range, and high storage capacity. Normal ROICs used today are generally optimized for one or two of these parameters but the design concepts to optimized all of these parameters has not yet been undertaken. In addition, the readout design must be capable of operating at 60Hz and provide A/D conversion on-chip to allow digital outputs off the FPA. Particular interests will be given to readout designs that incorporate novel dark current charge skimming (dark current subtraction) to address the limited dynamic range due to higher dark currents associated with QWIP detectors.

DESCRIPTION: This topic seeks to improve the current technology of C-QWIP detector infrared imaging by designing concepts for an advanced large format ROIC optimized specifically for CWIP detectors. Recent development in C-QWIP technology has shown improvements in quantum efficiency compared to the current QWIP technology. Due to the desirable feature of being fabricated on relatively mature GaAs/AlGaAs material systems, C-QWIP has shown to be a viable cost-effective candidate to meet US Armys needs for large format, high performance infrared imaging IRFPAs for persistent surveillance applications. To date, most of the C-QWIP infrared imaging demonstrations consist of mating C-QWIP detector arrays to existing ROIC designs or off-the-shelf ROIC designs. To realize the full performance of C-QWIP technology, readouts optimized specifically for C-QWIP detectors needs to be developed.

PHASE I: Investigate research and design readout architecture optimized for large format, high performance C-QWIP technology through the use of modeling, analysis, empirical testing or construction. Readout designs with innovative dark current charge skimming techniques are highly desirable. Establish working relationship with C-QWIP detector vendor to acquire C-QWIP detector arrays for possible phase II effort.

PHASE II: Using results of Phase I, design, develop and fabricate 2Kx2K, 15um pixel pitch ROIC. To demonstrate performance of ROIC, hybridize (mate) ROIC to C-QWIP detector array and evaluate performance of IRFPA through lab characterization. Develop and fabricate camera electronics to image the IRFPA. Deliver the C-QWIP imaging system/camera to the government.

PHASE III: Transition the C-QWIP technology to a production capable technology. The commercialization of this technology includes night driving aid, search and rescue, security, border patrol, fire fighting, and a host of other high performance infrared imaging applications.

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KEYWORDS: readout integrated circuits,electronics, infrared imaging, infrared focal plane array

A09-146 TITLE: Proactive Automatic Information Requests

TECHNOLOGY AREAS: Information Systems

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 U.S. Army has a need for improved automation at all levels of the Intelligence Surveillance Reconnaissance (ISR) and Command and Control (C2) processes. As the volume of information grows, it is increasingly difficult for an officer or a commander to anticipate all data that might critically impact the situation of a unit. ISR organizations and C2 staff are stressed to obtain, interpret, filter, distribute, and use a great body of information appropriately. This project will help commanders and their staffs to obtain succinct combat information while reducing their workloads.

This topic addresses a focused set of needs in support of Army Battlespace Awareness Force Operating Capabilities. Battlespace Awareness (BA) is an overarching, unifying concept mechanism to orchestrate and synchronize ISR operations across echelons, services, agencies and coalition partners, by enhancing collaboration, adding new capabilities, and in some cases, performing existing functions more efficiently and effectively [7].

DESCRIPTION: The present Distributed Common Ground System-Army (DCGS-A) is primarily reactive to commanders requests for information. An operator keys in Requests for Information (RFI) based upon his assessment of the commanders visualization. This visualization includes the commanders intent, planning guidance, general and specific doctrine, specific Commanders Critical Information Requirements (CCIR), and Essential Elements of Friendly Information (EEFI). Specific RFI are shaped by the knowledge of the commander and his staff. These individuals will ask for the information that they deem to be important. However, this approach limits the requests to what can be visualized by these individuals given their experience, their local information, the results of their previous information requests, and previous Indications and Warnings (I&W). The result is that a commander does not receive some critical intelligence items because no one determines beforehand that the information is critical to his units situation.

DCGS-A is a system that links a commander to a wealth of information concerning the combat environment. More specifically, a DCGS-A system is hosted on an appropriate computer with a link to information servers by way of a secure network. DCGS-A requires a human operator. The operator uses DCGS-A to fulfill CCIR and EEFI requests. Commanders use the results of these requests to develop appropriate actions within a combat environment or within Operations Other Than War (OOTW).

The U.S. Army desires an automatic I&W and RFI system that operates in conjunction with DCGS-A. This software item will proactively find information that is relevant to a units situation and offer the information to the commanders staff. Such information should be appropriately organized, starting with a succinct summary that includes a justification and explanation of relevance, and links to progressively detailed levels. The justification must be based upon a proven combat model which correlates critical variables to measures of combat power and in turn correlates well with combat results. In other words, such a system will assess a units situation in light of combat experience and offer information that the commander can use to gain advantages over the enemy.

A useful byproduct of this software is that CCIRs can be compared with what the software feels is most important. This provides an indication of how commanders are making their decisions and provides feedback to training commands.

Improving performance over time is a useful characteristic. The combat model can be updated using the databases available to a server. In this way, the system automatically learns; producing more relevant information as it gains experience with particular conditions, a specific theater, or mode of combat.

A third useful feature is that the software is capable of providing information to the militarys long-term planners regarding the key variables impacting those missions, theaters, or mode of combats that are expected in the future. This information is useful to improving organization, intelligence capabilities, logistics, other military functions, and weapons systems.

PHASE I: The contractor will develop a technical approach to facilitate innovative methods of automation including requirements, usage scenarios, and a prototype architecture for implementing effective automatic information requests in net-centric environments. The contractor will establish the feasibility including a technical risks assessment of the proposed approach.

PHASE II: The contractor will capture the specific operational scenarios within a Government specified domain. A prototype will be developed to demonstrate the capability of the system for use by the Army. The architectural significance of the device will be defined. Doctrinal issues will be addressed. The Phase II device will be integrated in a laboratory or simulated environment with the characteristics of the target tactical environments. Initial performance benchmarks will be defined and the system will be tested according to these benchmarks.

PHASE III: The end state of this project is effective automation of I&W and of RFI across the Global Information Grid (GIG) by multiple Government organizations. This automation will improve combat performance by minimizing information disuse and stagnation while minimizing command workload. Army applications include use of the technology by stakeholders in all stages of the ISR analysis workflow. Similar needs exist in the other services, homeland defense, and intelligence agencies. Phase III applications may involve joint and cross-organization operations. Candidate Army transition programs include Aerial Common Sensor (ACS), DCGS-A, and Future Combat Systems (FCS). Potential dual use would be the application of this technology in commercial organizations to improve the production of critical decisions about competitors, customers, suppliers and new markets.

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KEYWORDS: Distributed Common Ground System, Information Request, Combat Planning, Battlespace Awareness, Intelligence Surveillance Reconnaissance

A09-147 TITLE: Helmet Mounted Radar System (HRMS)

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a miniature, low power, near 360-degree field of view Moving Target Indicator (MTI) radar sensor that will alert the soldier to the whereabouts of a target out to at least 25 meters. The sensor is to be mounted, embedded, and integrated within the Advanced Combat Helmet and associated sensor suites.

DESCRIPTION: With the emerging threat of urban warfare, soldiers need a reliable, lightweight radar system that detects and locates close range targets and cues the soldier to the target's location. In urban warfare, dismounted warfighters can come from any direction, thus the system shall provide a near 360-degree field of view (FOV) and detect dismount targets out to 25 meters, with a goal of 50 meters. Special attention should be given to the weight and power consumption of the system. The total weight of the system should be < 2 1/2 pounds and the portion of the system mounted on the helmet should be < 1 pound. The effective radiated power of the system has to be low enough not to affect the health of the soldier. The contractor shall develop an innovative concept that will be utilized in the detection of targets and alert the soldier to the whereabouts of the targets. The radar system shall be capable of being mounted, embedded and integrated within the Advanced Combat Helmet and associated Sensor suite. An objective requirement for the system is to have usage of the system while under coverage, alertness to other blue force entities, and the detection of small arms fire.

PHASE I: The contractor shall conduct a feasibility study to develop a miniature, low power, Moving Target Indicator (MTI) radar system that can be mounted, embedded and integrated within the Advanced Combat Helmet and associated Sensor Suite. The contractor shall submit a report which will be a feasibility study of the methods and radar sensors used to perform this mission. The report should contain a description of the radar sensors, and the method for taking the radar data from the sensors and cueing the soldier to the whereabouts of the target.

PHASE II: The contractor shall develop a prototype system based on the findings of the Phase I feasibility effort. A demonstration of the prototype system will be conducted at a location determined by the government.

PHASE III: Based on Phase II results, the system will be improved upon and optimized for integration with the Advanced Combat Helmet. The system will be used to demonstrate its target detection and cueing capabilities at a location determined by the government. Several specific military/commercial programs that can benefit from this system include Law Enforcement agencies, Department of Homeland Security, Customs and Border security, etc. Potential Commercial applications that can take advantage of this technology include remote stand-alone MTI radar for perimeter awareness, vehicular accident avoidance, environment awareness for law enforcement agencies, etc.

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KEYWORDS: Helmet Radar, Moving Target Indicator, Sensors, Signals Intelligence (SIGINT)

A09-148 TITLE: Tunnel Detection using MASINT Techniques

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Develop a suite of sensors that will detect, and locate tunnels. The system will be able to determine the depth of the tunnel and map the location of the tunnel on an overlay of a map. The system should also be able to determine if the tunnel has power and be able to detect the presence of human beings.

DESCRIPTION: Tunnels are used for a variety of reasons, to smuggle people across borders illegally, to smuggle weapons behind enemy lines and to perform terrorism. The tunnels can be large enough for a man to walk upright, have power for lights, power for air and noxious gas removal. They can be small and shallow, just large enough for a person to crawl through. The tunnels essentially make voids in the earth which make them susceptible to detection by seismic/acoustic techniques. The larger tunnels with power and conduit to hold power lines are detectable through electromagnetic techniques as well. The tunnels if not properly ventilated or even with ventilation have to filter the air and this gas is detectable. The contractor shall develop an innovative concept that will be utilized in the detection, location and mapping of these various detection parameters and tunnels.

PHASE I: The contractor shall conduct a feasibility study to develop a suite of sensors that would be necessary to detect tunnels. The methods used for the detection of the tunnels can be seismic/acoustic, electromagnetic and/or chemical sensors. The contractor shall submit a report which will be a feasibility study of the methods and sensors used to perform this mission. The report should contain a description of the sensors, the method for taking the data from the sensors and turning this into useful information to determine if there is a tunnel and where this tunnel is located.

PHASE II: The contractor shall develop a prototype system based on the findings of the Phase I feasibility effort. The prototype system will be able to map the physical dimensions of the tunnel and location of the tunnel and display this location overlayed on a map of the local area.
The system should also be able to display other characteristics of the tunnel such as power. 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. The system will be used to demonstrate its tunnel detection capabilities at a government facility such as Yuma Proving Ground or facility with some sort of tunnel system. The system will also be tested at border areas where tunnels have been know to be used to smuggle contraband into the United States. The system will also be demonstrated in areas where the government feels there is a possibility of tunnel activity that could compromise the security of U.S. interests. Several specific military/commercial programs that can benefit from this system include Forward Operating Bases (FOB), URBAN SABRE, Sense Through The Wall (STTW), military encampments, Law Enforcement agencies, Department of Homeland Security and Customs and Border security.

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KEYWORDS: Sensors, seismic, acoustic, electromagnetic, chemical detection, Measurement and Signature Intelligence (MASINT)

A09-149 TITLE: Visual Measurement Based Autonomous Navigation

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Demonstrate a visual based electro optic device that provides navigation data for use in place of an inertial measurement unit (IMU) in a soldier navigation system. The demonstration must show that the performance is not tied to temperature and be on the order of a 0.5 deg/hr MEMs IMU.

DESCRIPTION: Soldier navigation systems currently consist of a Global Positioning System (GPS) receiver and possibly an inertially based measurement device to determine the motion of the soldier. When these are coupled, the two work very well together, providing Position Location Information (PLI) to the soldier. In a navigation system, the GPS provides highly accurate PLI and keeps the errors in the inertial device constrained, while the inertial device lends robustness to the navigation solution. Inertial devices used for personal navigation systems must be small, light weight, very power efficient, and low cost. These constraints lead to the use of units with poor accuracies and high error growth mechanisms that drive the performance and cause the unit to degrade rapidly in the absence of GPS. Error growth is primarily dependent upon time or distance travelled, and low grade systems quickly exceed acceptable performance parameters without inputs to restrict the error growth, thus rendering the unit ineffective in a matter of a few minutes. This situation is especially critical when operating in conditions where GPS is unavailable, such as a GPS denied battlefield, under foliage, in and around natural mountains/canyons, or more recently pertinent, urban conditions.

A video based device could replace the inertial sensor in a soldier navigation system by providing velocity and position information based on object recognition and measurements made upon those objects. The distinct advantage here is that this type of system inherently offers the opportunity to meet the need for low cost, light weight, low power, and small size in a device that does not have an error mechanism that depends on temperature or grows with time/distance traveled. Current video based navigation solutions require an Inertial Measurement Unit (IMU) that is relatively large, heavy and expensive. We are seeking an innovative method for using visual object recognition to autonomously determine PLI without auxiliary hardware for use in a soldier navigation system. This concept eliminates the need for an IMU, replacing it within the navigation system.

PHASE I: T he vendor shall investigate methods and develop algorithms to use with a video based device in order to recognize objects, make measurements, and calculate the attitude, position, and velocity of the camera in real time. This should initially be conducted with smooth and steady motion to verify and improve upon the technique, but later dynamic disturbances should be introduced to the field of view that are similar in nature to motions of the human body. The vendor shall determine what error mechanisms impact potential devices and analyze them to predict the expected performance. Using this error analysis, the vendor shall explore meothods to mitigate the errors and prepare a model/simulation to test the veracity of the techniques developed and use this tool to demonstrate the potential capability.

PHASE II: Based on the results from phase I, the vendor shall develop a prototype visual based system and experimentally demonstrate the feasibility of navigating with a camera in place of an IMU. This demonstration should include a scenario where GPS is available and then transition to a GPS hostile environment, such as an indoor scenario, which is especially important as GPS is not available. This phase must include considerations for size, weight, power, and cost to be useful for soldier navigation systems. Investigations should include the fidelity and performance of cell phone cameras (extremely small size, weight, power, and cost) as candidates for use as soldier sensors.

PHASE III: The vendor shall further refine the development of a camera based autonomous navigation system for a field demonstration on an individual. This includes more involved considerations such as the human gait, robustness, and degraded visual conditions. Development should also include uses by other potential customers such as fire fighters, automotive applications (both military and commercial), unmanned air/ground vehicles (UAVs/UGVs), etc. In particular other Army efforts that may benefit from this development include: the Military 3D Locator, RF ADaptive technologies Integrated with Communications And Location (RADICAL) Army Technical Objective (ATO)l, and Assured Position and Navigation efforts in the Communication-Electronics Research, Development and Engineering Center (CERDEC) Command and Control (C2) Directorate as well as the Advanced 3D Locator development effort currently being conducted by the Department of Homeland Security.

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KEYWORDS: Global Positioning System (GPS), Inertial Measurement Unit (IMU), Navigation System, Position Location Information (PLI), Simultaneous LocalizationAnd Mapping (SLAM),

A09-150 TITLE: Problem Conceptualization & Resolution of Network Problems in Tactical Environment

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Research and develop innovative algorithms, cognitive visualization, correlation and reduction technologies for the presentation of mission relevant network operations (NetOps) data. Information needs to be presented in such a way that an unskilled operator can understand the complexities of a tactical network.

DESCRIPTION: Acquiring and maintaining NetOps situational awareness is a key task of any network operator in defense of the Global Information Grid (GIG). Accomplishing this task currently requires a skilled network engineer. Only with these skills can the network operator fully understand, maintain, and diagnose the status of the network. Tactical network management operators often come in with a
limited amount of training and are responsible for problem resolution of complex systems which are abstract or do not have good physical world references.

Existing commercial off the shelf (COTS) network monitoring tools are designed for skilled users who understand networks, and not networks with the characteristics of a tactical environment. Tools are designed for static networks where loss of connectivity is atypical. In a tactical network, problems such as error rates, packet drops, resource contention and system mis-configuration are typical and usually require an in-depth understanding of the systems in order to be resolved.

New tasks, emergencies, and other distractions increase the burden on the operator as the situational status of the network, its environment, and the mission must be reacquired. Unfortunately, the current generation of network operator systems are based on conventional commercial operational support systems (OSS), and often do not take into account recent advances in our understanding of the human visual system, or in human-centered computing, and thus to not provide any cognitive load reducing benefits. Instead, they just provide data and expect the operator to be able to integrate it all, while simultaneously accomplishing other tasks.
Traditional displays require the network operator to scan the raw data, looking at various systems in succession in order to obtain needed information. Examples include determining the relationships spectrum management, network monitoring, security and access control policies. Studies of system scanning have shown that the amount of time an operator views a system is affected by such factors as the type of system, the operators workload at the time,

mission type, and the operators expectations. It is not unusual for even trained network operators to spend as much as 0.5 to 2 sec viewing a single item of data. The delay imposed by the requirement to gather information sequentially can be substantial, severely limiting the operators ability to cope with rapidly changing or unanticipated situations and emergencies. Furthermore, the operator must constantly monitor systems to ensure that the network is performing as intended. Rapidly understanding deviations from a prescribed mission plan is particularly important for network operators, who often switch between network planning, network execution, network monitoring, and network replanning.

PHASE I: Observe and research problem resolution of untrained network management operators of tactical networks in high stress environment and come up with techniques and feedback processes to maximize performance. Categorize the different types of problems a tactical network operator is subject to. Perform user studies observing untrained operator behavior in resolving network problems. Research the techniques and feedback systems in order to optimize operator performance and test their success on real operators. Provide a paper documenting the best processes for problem resolution in the tactical environment.

PHASE II: Implement the best approach resulting from the documented reports in Phase I. Deliverable includes prototype software that will be demonstrated and tested Communications-Electronics Research, Development, and Engineering Center (CERDEC). Deliverable final report will include the final design, as well as test results, and any results of modeling and simulation. It must also demonstrate how it generates relationships between various information sources.

PHASE III: Develop fully functional system as described in Phase II and refine to the degree necessary to transition into a Program of Record. Deliverables include final product, any documentation associated with product, as well as all modeling and simulation results .

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KEYWORDS: Cognitive; Heuristic; Relationships; Optimization; Patterns; Information

A09-151 TITLE: <u>In-situ Stress and Temperature Optical Monitoring for low-cost heteroepitaxial substrates for HgCdTe infrared detectors.</u>

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: To design a concept for real-time temperature, stress, and reflectivity monitoring during the MBE (molecular beam epitaxial) growth of HgCdTe/CdTe layers on low-cost large-area substrates.

DESCRIPTION: II-VI compound semiconductor alloys of HgCdTe have been shown to be ideal materials for detecting infrared radiation at wavelengths of tactical and strategic interest. Next-generation systems are envisioned to entail large-format (>1M pixels), infrared focal plane arrays (IRFPA) for applications such as persistent surveillance and beyond-the-horizon enhanced horizontal field of view systems. Such systems will only be realized through the use of low-cost large format composite substrates such as CdTe buffered Si, or GaAs. The traditional substrate material, Cadmium Zinc Telluride (CZT), is not made in large format sizes and is available only from a foreign vendor. Fabrication of large area composite structures will be difficult due to large lattice and thermal matching between the CdTe buffer layer and the Si or GaAs substrate. More critically, the growth of II-VI material (HgCdTe, CdTe) is highly temperature dependent and the temperature measurements within a high vacuum environment are very challenging. What would be ideal is an optical sensor that could be used non-destructively through a port window to monitor critical growth parameters like temperature, stress and surface morphology. Recent advances in the CdTe/Si and CdTe/GaAs growth technology have come from improved growth recipes, derived from in-situ annealing and interface engineering studies.

Further improvement in these composite substrates is required to reduce the density and propagation of crystalline defects that would degrade the subsequent HgCdTe device overlayer. In-situ annealing processes could be further examined and optimized by monitoring the overall stress and temperature states of the deposited film in real time. Simultaneous monitoring of accurate substrate surface temperature is also necessary for improved understanding of the annealing process. For Si, commercially available pyrometers do not permit the full temperature range used during CdTe MBE because the surface properties change as CdTe is deposited. For example, accurate substrate temperature measurement is complicated by changes in surface emissivity during growth. Reflectance monitoring could be employed for emissivity correction as well as thickness/growth rate measurements.

PHASE I: The contractor shall establish the feasibility of apparatus capable of performing real-time (non-contact) optical temperature surface monitoring in the range 25-800 deg C on Si, GaAs, and CdTe, in addition to real-time stress and surface reflectivity monitoring. This should include a feasibility demonstration on bare and CdTe buffered substrates provided by NVESD. NVESD will also provide HgCdTe epitaxial layers for feasibility demonstration of stress and reflectivity monitoring. A plan for incorporation of the apparatus into an existing VG80H MBE system should be included, with attention to the need for monitoring during substrate rotation.

PHASE II: The contractor shall complete design and development as well as fabrication of the temperature/stress/reflectivity monitoring apparatus for MBE growth of CdTe on Si and GaAs substrates. The field testing will be critical to the performance and acceptance of the optical based measurement system.

PHASE III: Successful completion of Phase II, followed by validation of apparatus by government experts, will likely lead to great interest from the II-VI thin-film growth industry. It is anticipated that several major corporations seeking critical real-time growth metrics (for improved yield) would purchase the tool. Revenue from service agreements would maintain the small business.

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KEYWORDS: in-situ Stress monitor, heteroepitaxy, thin-film, HgCdTe, Si, IRFPA

A09-152 TITLE: Develop a Point-of-care Antigen Assay for Rickettsial Early Diagnosis

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Rickettsial pathogens have been a leading cause of morbidity and mortality during military operations. Currently there are no FDA-cleared, field-usable assays that can be used to diagnose rickettsial disease in sick soldiers. The goal of this topic is to develop the capability to detect rickettsial antigens/pathogens in sick soldiers blood for early diagnosis within one week after the on set of illness to compliment the development of on going antibody based diagnosis. We envision a rapid point-of-care, hand-held device that is capable of determining whether a sick soldier is infected with rickettsiae. The assay should be at least 85% as sensitive and specific as current (non-deployable, non-FDA cleared) assays. The assay must be soldier friendly (little or no training required), rapid (<30 min), easy to operate (one- or two-step), inexpensive, portable, and all reagents must be heat-stable (at 35 degrees C for 2 years) without the requirements for special storage.

DESCRIPTION: Rickettsial pathogens have been a leading cause of morbidity and mortality during military operations. Many different organisms fall under the name of rickettsial pathogens which cause a variety of diseases. In recent years, emerging rickettsial disease has been reported throughout the world and is a significant medical concern for local and deployed personnel and travelers [1]. The most militarily relevant pathogens are the spotted fever group Rickettsiae (Rocky Mountain spotted fever, Rickettsial Pox, Boutonneuse fever, Siberian and Australian tick typhus, and Oriental spotted fever) and the typhus group Rickettsiae (epidemic and murine typhus).

Due to the high mortality rate that can result from untreated rickettsial infections, early treatment with appropriate antibiotics is critical [2]. Doxycycline is the drug of choice for the infections caused by Rickettsia except in cases of pregnancy and tetracycline hypersensitivity. Symptoms of many rickettsial infections are easily confused with a variety of other pathogens (e.g., dengue, malaria, leptospirosis, etc.) that require different treatment regimens. In order to ensure that appropriate treatment is initiated promptly, the early diagnosis of rickettsial infections is critical. Currently, the diagnosis of rickettsial diseases relies mainly on serological methods [3, 4]. Hand-held assays specific for spotted fever group and typhus group Rickettsia are in the process of being developed. These tests are all based on antibody detection. However, antibody based assays may not be adequate for the diagnosis of patients in acute phase as antibody levels may not be detectable at the onset of illness. Therefore, antigen/pathogen detection before the rise of antibody level is important. Almost all antigen/pathogen detection for rickettsial diseases is based on polymerase chain reaction [5, 6]. This approach requires sample processing (DNA extraction), sophisticated instrumentation, expensive temperature sensitive reagents, and extensive training of the end user. Its application is suitable for the hospital based laboratory, but not for point-of-care in a rural area.

The goal of this SBIR topic is to develop the capability to detect rickettsial antigens/pathogens in sick soldiers blood soon after the onset of diseases. We envision a rapid point-of-care, hand-held device that is capable of determining whether a sick soldier is infected with rickettsiae. The assay should be at least 85% as sensitive and specific as current (non-deployable, non-FDA cleared) assays. The assay must be soldier friendly (little or no training required), rapid (<30 min), easy to operate (one- or two-step), inexpensive, portable, and all reagents must be heat-stable (storage at 35 degrees C for 2 years) without the requirements for special storage.

PHASE I: Selected contractor demonstrates the feasibility of the concept by developing a prototype diagnostic assay for antigen/pathogen detection using its selected technology that has the potential to meet the broad needs outlined in this topic. The assay must detect all rickettsial diseases (spotted fever group and typhus group). The assay should be able to further differentiate spotted fever group and typhus group Rickettsia when it is necessary. Selected contractor should coordinate with the contracting officers representative (COR) for access to required reagents and control materials from DoD. A limited supply of reagents and control materials may be provided by Naval Medical Research Center (NMRC) (these reagents may not be sufficient to complete all work required by the contract the contractor may have to obtain additional reagents from sources other than NMRC). The selected contractor provides prototype device/assay format and reagent sufficient to evaluate 100 samples to the COR for initial laboratory testing at the NMRC at the conclusion of Phase I. Data from independent testing at the NMRC will be used as a factor in determining award of Phase II contracts.

PHASE II: The selected contractor provides at least 300 prototype devices/assay format and reagents to evaluate 100 samples to the COR each time. Feedback regarding the sensitivity/specificity of prototype device/assay format will be provided to the contractor at the end of each evaluation this data will then be used to optimize and improve each subsequent design of prototype device/assay format. The goal in Phase II is the development of a prototype device/assay format that provides 85% sensitivity and 85% specificity when compared to current gold standard assays for rickettsial diseases. Once sensitivity/specificity requirements have been met, the selected contractor provides a final prototype device/assay format and reagents sufficient for evaluating of 500 samples to the COR for laboratory confirmation of assay performance characteristics (sensitivity, specificity, positive and negative predictive value, accuracy, reliability and limit of detection) and initial field testing. The selected contractor will also conduct stability testing of the prototype device/assay format in Phase II. Stability testing will follow both real-time and accelerated (attempt to force the product to fail under a broad range of temperature and humidity conditions and extremes) testing in accordance with FDA requirements.

PHASE III: During this phase the performance of the assay should be evaluated in a variety of field study sites that will conclusively demonstrate that the assay meets the requirements of this topic. The selected contractor shall make this product for sale to military and non-military users throughout the world. The selected contractor is recommended to carry out studies required to obtain FDA clearance for the assay.

Military applications: Rickettsial diseases are widely distributed throughout the world as zoonotic cycles in foci of endemicity, with sporadic and often seasonal outbreaks developing. Historically, infection with typhus group rickettsia was responsible for greater than 30 million cases of typhus during and immediately after World War I, causing about 3 million deaths. The recent outbreak of louse borne typhus in refugee camps in Burundi, which involved thousands of human cases with the mortality rate exceeding 10%, reminded us that rickettsial diseases can re-emerge in epidemic forms as a result of the catastrophic breakdown of social conditions. The Armed Forces Medical Intelligence Center (AFMIC) last year ranked spotted fever and murine typhus as the 22nd and 25th highest global risk-severity index (GRSI) disease, respectively, among 53 infectious diseases of military significance. The real threat to deployed soldiers is much higher than the current view because there are no good diagnostic assays and cases are always under reported, especially in those developing countries where the disease is endemic. The diagnosis of these cases is often delayed, because the similarity of symptoms with other febrile diseases and that there are no FDA-cleared rickettsial tests currently available. With the availability of an easy and rapid assay developed under this topic, sick soldiers will be treated in a timely manner in any military medical organization (such as a Battalion Aid Station, a Combat Support Hospital, Forward operation base, or a fixed medical facility). Once a National Stock Number (NSN) has been assigned to the assay, it will be incorporated into appropriate "Sets, Kits and Outfits" that are used by deployed medical forces.

Civilian applications: Rickettsioses are a good example of diseases whose importance is not adequately appreciated, except by patients. It is a widespread zoonotic disease. In the US, drastic increase in the number of cases of murine typhus and Rocky Mountain spotted fever (RMSF) occurred in the 1940 and in the late 1970s, respectively. Additional human pathogens are being identified in areas of the world where rickettsioses had not previously been investigated in depth. Political unrest and major changes in social conditions have led to small outbreaks of rickettsial diseases in various parts of the world. Civilians in these areas are subjected to great danger. We envision that the contractor that develops the rickettsial assay will be able to market this assay to a variety of civilian medical organizations, and that this market will be adequate to sustain the continued production of this device.

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KEYWORDS: rapid diagnosis, antigen/pathogen detection, point-of-care, rickettsial diseases,

A09-153 TITLE: Wearable Fiber Optic-Enabled Chemical Nanosensor Array for Warfighters

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical, Human Systems

OBJECTIVE: Develop a novel lightweight, low power and inexpensive smart porous silicon sensor capable of reliably detecting one or more non-agent volatile organic chemical compounds (VOCs). Demonstrate signal capture, signature analysis, and digital data packet generation.

DESCRIPTION: Develop and demonstrate a minimalistic chemical nanosensor that is low-cost, lightweight, and suitable for use by dismounted Warfighters operating in harsh environments. The ideal prototype sensor would (a) be based on optically-interrogated porous-silicon, PSi, nanosensor technology, (b) incorporate digital signal processing, and (c) be capable of reliably detecting, classifying and providing the airborne concentration of one or more TICs (toxic industrial chemicals). The sensor will ultimately be used to improve chemical situational awareness of military personnel by (a) detecting, classifying, quantifying, and reporting chemical species contained in air and/or expired breath, and (b) enabling prompt (within tens of seconds) detection, characterization, and local annunciation of exposure to a range of environmental chemical threats such as volatile organic compounds.

Advances in the understanding of the manufacture of PSi, new techniques for suppression of background interference in PSi-based sensors, successful encoding of PSi rugate filters for multiple analytes together with demonstrations of compact optical fiber sensor smart nodes intended for embedded use allow for the possibility of an ultra-compact, powerful, low-cost, physically-robust sensor that does not necessarily require power at the sensor node. Significant challenges remain in adapting this technology for use by the Warfighter, specifically in miniaturizing the sensing element and providing a useful signal over a wide range of environmental conditions. Accuracy, durability, and insensitivity to heat, dust, changes in humidity; precision, reliability, reversibility, and sensitivity to target analytes; simplicity, speed of operation, low power-consumption, low weight, small physical size, low cost, minimal logistical burden, and ease of use are all desired sensor characteristics.

The ultimate goal is to develop a sensor with detection limits for target analytes consistent with the medical threat represented by the analyte e.g., benzene 0.04 ppm, xylene 17 ppm, toluene 7 ppm, acetone 170 ppm. (This list is for reference only and is not intended to be either definitive or complete. Required detection limits for any analyte of interest may be estimated as one-third of the most conservative time weighted average (TWA) exposure threshold limit value found on a given substances current MSDS.) Technologies proposed must show a clear developmental path towards providing this level of sensitivity. Target analyte concentration derived from the sensor should be in close correspondence to reference measurements. Sensor reversibility is required, that is, quick clearing or reset of a previously exposed sensor.

System response times of a very few tens of seconds, or less, not minutes or hours, are needed. The sensor must operate reliably, with minimal calibration requirements. The sensor technology should exhibit good selectivity, providing the desired information regarding the triggering analyte without significant interference from other compounds. Ideally, the technology should ultimately be able to detect, classify and report the concentration of a variety of analytes in the presence of interfering compounds. To facilitate eventual use in networked applications, sensors must be capable of providing information in digital format (e.g., unique identification number, time of detection event, analyte class and concentration, sensor status) in response to an external query. Experimentation with human test volunteers will not be needed.

PHASE I: Initiate development of a smart porous-silicon sensor capable of detecting one or more volatile organic compounds. More specifically, define methods to reliably produce porous-silicon with the desired characteristics. Explore innovative methods of producing millimeter-sized sensor elements. Define approaches to optically interrogate sensor element and generate digital data. Initiate efforts to assess sensor performance (sensitivity, reliability, regenerability, response to varied humidity, etc.), power requirements, and general feasibility for field use.

PHASE II: Develop and demonstrate an advanced prototype sensor (Technology Readiness Level 4: Component and/or breadboard validation in a laboratory environment)(TRL Explanation Biomedical TRL Explanation). Demonstrate selectivity, reliability, insensitivity to common interferents, and stability towards zero point drift. Demonstrate the detection and discrimination of two or more target volatile organic compound (VOC) analytes under conditions of 25-75% relative humidity and -10 to 55 deg C. Demonstrate digital data sensor output. Develop and deliver at least five advanced prototype sensor systems. Provide a technical path forward to an advanced sensor capable of multi-analyte detection in air and expired breath under field conditions.

PHASE III: Other DoD, non-DoD Governmental and private sector applications for the technology should be identified and vigorously pursued by the offeror. This technology could be used in mobile, portable and static applications. Because the threat of exposure to harmful level of volatile organic compounds exists across a wide array of workplace and operational environments, this technology would be useful in risk mitigation, threat detection, and acute and chronic exposure assessment of large populations.

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KEYWORDS: Ambulatory monitoring, wearable sensor, nanotechnology, porous silicon, chemical awareness, toxic industrial chemicals

A09-154 TITLE: In Vivo Stem Cell Extraction Device

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: To develop a cell extraction device (that can be easily implanted) for stem cell collection, enrichment, and extraction (e.g. in the blood) with sufficient cell numbers for rapid regenerative medicine applications. Device should be safe for use with injured patients. Ideally, the device should be low cost and off-the-shelf for single use.

DESCRIPTION: Currently, there are few to several devices and processes for which stem cells are collected and expanded. For example, bone marrow stem cells have been traditionally obtained through bone marrow aspiration, which requires general anesthesia and causes pain and discomfort. An easier and less painful alternative process known as mobilization can be used and involves injection of a medication that temporarily results in the stem cells (residing inside the bone marrow) to move into the peripheral blood. Then apheresis is used to separate and collect the stem cells from the peripheral blood. This process is typically aimed at a healthy person, who wants to collect and preserve the collected stem cells for later use. Thus, it remains to be determined whether an injured person can undergo this process with additional risks. Another alternative process includes extraction of stem cells from adipose tissue. Generally these methods require additional ex vivo processing for obtaining stem cells of interest as well as expansion ex vivo to achieve sufficient cell numbers for regenerative medicine applications. The greatest hurdle with any stem cell collection device or process is harvesting sufficient cell numbers for rapid regenerative medicine applications. Ideally the device should harvest sufficient cell numbers so it does not require ex vivo expansion, which sometimes can change the cell properties and its abilities such as engraftment. Therefore, it is envisioned an in vivo stem cell extraction device for which selectivity and enrichment can be controlled through engineering designs and understanding of cell biology, could potentially provide sufficient cell numbers for rapid regenerative medicine applications. Specific regenerative medicine applications of interest include improving wound healing and regenerating loss tissue due to traumatic injuries.

PHASE I: Conceptualize and design an innovative plan for constructing a prototype device that will selectively isolate stem cells to result in sufficient cell numbers for rapid regenerative medicine applications. This research plan should result in the construction of a prototype device for proof of concept without conducting animal studies. Required Phase I deliverables will include a conceptual design (i.e. blueprints of the design to include implant and removal of device) and a prototype of a device that demonstrates isolation of stem cells from a cell mixture with high efficiency. The design should be based on sound engineering principles, an understanding of cell biology, and knowledge of the human physiology.

PHASE II: Develop, demonstrate, and validate prototype device designed in Phase I for in vivo stem cell collection, enrichment, and extraction with sufficient cell numbers for rapid regenerative medicine applications (i.e. do not require ex vivo expansion process/bioreactor). Implantation and removal of the device should be safe for use with injured patients. Pre-clinical testing of the device should be included. Conduct life cycle and environmental testing to ensure the device can be used off-the-shelf with minimal requirements (i.e. ambient storage) and reasonable shelf-life. Develop plans to result in low cost production of the device. Establish performance parameters through experiments and prototype fabrication.

PHASE III: Traumatic injuries occur in both civilian and military populations and oftentimes treatments do not result in optimal outcome. The intent of this SBIR topic is to support the development of a safe, implantable, and removable stem cell extraction device that could selectively isolate stem cells of interest at sufficient cell population without the need for ex vivo expansion so that it could be used for rapid regenerative medicine applications. Phase III is intended to support and test the device for various regenerative medicine applications, including conduction of relevant large animal (pre-clinical) studies for generating data to support application of an IND application with the FDA, and may also include demonstrated manufacturing process for quality production of devices for medical grade application for support of clinical studies. Therefore, partnership with clinicians and other relevant experts may be necessary to identify an injury for repair through implementation of the device. The end goal would result in obtaining sufficient data for Phase I clinical trial and an IND application. This device is envisioned to be used in treatment of injuries where regenerative medicine would most likely result in the best functional and aesthetic outcome where current surgical and other treatment options are inadequate. It is intended to be used at fixed medical facilities and the device needs to be off-the-shelf.

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KEYWORDS: Stem cells, device, cell sorting, cell enrichment, cell isolation

A09-155 TITLE: Development of a Simple and Rapid Assay for Field Detection of Dengue Viral RNA

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: To develop and field a point-of-care molecular assay for sensitive and specific detection of dengue viral RNA for the early diagnosis of all serotypes of dengue infection.

DESCRIPTION: Dengue fever is caused by dengue virus, an enveloped, single-stranded positive sense RNA virus of the family Flaviviridae (1). Greater than 50 million infections are reported each year, with over 40% of the worlds population at risk (2). Dengue virus is transmitted predominantly by the mosquito species Aedes aegypti, which breed in urban dwellings primarily in tropical and subtropical regions. As a result of increased travel and the ubiquitous nature of the Aedes vector, dengue fever is now endemic in more than 100 countries. Due to its worldwide prevalence, dengue fever is currently ranked 3rd among infectious disease threats of military significance (3). Developing the capability to rapidly and accurately distinguish dengue infections from other febrile illnesses is critical to providing proper healthcare to our military and civilian personnel.

Presently there are no FDA-approved vaccines, drugs, or diagnostic devices for the prevention, treatment or detection of dengue fever. Traditional laboratory techniques such as virus isolation followed by indirect immunofluorescence assay are labor intensive, and can require weeks to obtain results. Newer technologies such as real-time PCR allow for more rapid identification of dengue during acute illness, but require expensive, cumbersome equipment that is not practical in the field. The objective of this topic is to develop an assay or device that allows for simple, rapid isothermal amplification of all serotypes of dengue virus RNA. An example of such technology is the recently described loop-mediated isothermal amplification (LAMP) technique (4). The assay must be capable of detecting circulating levels of dengue virus from patient samples with minimal sample processing up to 7 days post-onset of symptoms, with sensitivity and specificity equivalent to current nucleic acid detection systems. Desired characteristics also include: 1) ease-of-use (1-2 steps), 2) reagent stability in tropical climates, 3) speed (<60 minutes), and 4) ease of interpretation of results. The assay should also be capable of point-of-care usage, either as a hand-held device or requiring no more than an inexpensive, battery operated system.

We envision that the rapid diagnostic assay developed under this SBIR topic will be FDA approved for use by the military at the point-of-care. This can lead to more targeted medical treatment, and limited disease outbreaks among military personnel due to enforced personal protective measures. This assay could also be used in rapid screening of blood-banks for the presence of dengue, which is a significant problem during transfusions in dengue endemic regions. Due to the ease-of-use and inexpensive nature of this prototype, we envision widespread use by regional medical clinics and non-governmental organizations (NGOs) around the world.

PHASE I: The selected contractor will determine the feasibility of the concept by providing a detailed design and development plan for a prototype diagnostic assay that has the potential to meet the characteristics discussed in this topic. The assay must be able to detect RNA of all serotypes of dengue virus from patient samples within one week of onset of febrile illness. Other broad needs include ease-of-use, stability of reagents in tropical climates, and minimal need for expensive, cumbersome equipment. The selected contractor should coordinate with the Contracting Officer Representative (COR) for access to required reagents from the Walter Reed Army Institute of Research (WRAIR) or the Naval Medical Research Center (NMRC). At the conclusion of Phase I time permitting, the selected contractor may provide the COR an assay prototype for independent evaluation which is capable of amplifying all serotypes of dengue virus with minimal scientific expertise and equipment required. Prototypes should include a positive and negative control in each assay. The contractor will also identify feasible approaches for the determination of positivity of a sample which meet previously mentioned criteria. The degree to which the prototype assay development plan and/or supplied prototype corresponds to the desired capabilities will be used in the determination of Phase II awardees.

PHASE II: The goal in Phase II is the successful refinement and validation of a prototype assay that provides optimum sensitivity and specificity when compared to the current gold standard assays of dengue virus detection (virus isolation and/or Real Time-PCR). This prototype must be either hand-held, or require only battery-operated, portable equipment. The prototype should also be stable enough for transportation without a cold chain, storage at room temperature, and use in high humidity tropical climates. The down-selected prototype should also allow use of whole blood with minimal sample processing, and require no special equipment to determine positivity of a sample. Once these requirements have been met, the selected contractor will begin comprehensive pre-clinical evaluations of assay performance in regions both non-endemic and endemic for dengue fever. These evaluations must be in accordance with FDA requirements in preparation for a 510(k) application. Characteristics to be tested include: 1) sensitivity (85% or greater compared to gold standard test) and specificity (85% or greater compared to gold standard test) 2) limit of detection (10 plaque-forming units (PFU) or less) 3) Cross-reactivity with other fever-causing agents and 4) reproducibility/stability. The selected contractor may coordinate with the COR to facilitate field site testing and collection of clinical specimens. As successful completion of Phase II will require assay validation on clinical samples, the Phase II proposal must contain a comprehensive strategy for use of human specimens. This includes types of specimens to be tested, potential trial sites, identification of the Institutional Review Board (IRB), and a Federal-Wide Assurance of Compliance.

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, resulting in a 510(k) submission to the FDA. Once FDA-approved, the assay will be assigned a National Stock Number (NSN) and incorporated into appropriate Sets, Kits and Outfits to be used by deployed medical forces. The selected contractor shall make this product available to potential military and non-military users throughout the world.

This assay will be suitable for use by far-forward military medical units (e.g. Battalion Aid Station) or medical personnel (e.g., Special Forces medics) to determine if sick military personnel are infected with dengue. This assay may also be useful to the military for surveying mosquito populations for dengue virus, allowing vector control measures to be implemented before a disease outbreak occurs. This simple, inexpensive assay will also be ideal for non-military medical purposes, such as use by regional medical clinics or non-governmental organizations (NGOs) in areas of the world where dengue is endemic (e.g., most tropical regions of the world including South-East Asia and South America). In addition to its usefulness in patient diagnosis, this assay is also amenable to other applications such as blood-bank screening during epidemics. Because dengue fever is one of the worlds most common infectious diseases, we believe that the contractor that develops this assay will be able to sell and/or market this product to a variety of civilian medical organizations, and that this market will be adequate to sustain the continued production of this device. This assay may also serve as proof-of-principle for the usefulness of isothermal gene amplification at point-of-care, and could easily be adapted to other infectious diseases, thus creating a sustainable and profitable product pipeline for the contractor.

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KEYWORDS: dengue virus, DENV, point-of-care, diagnosis, virus detection, loop-mediated isothermal amplification (LAMP)

A09-156 TITLE: Development of a Multiplex Hand-held, Field-deployable Assay for the Detection of Tick-borne Encephalitis Virus (TBEV), Crimean-Congo Hemorrhagic Fever Virus (CCHFV), and Rickettsia in Ticks

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Adapt state-of-the-art technology to develop a hand-held, field-deployable assay capable of detecting and identifying with one assay TBEV, CCHFV, and Rickettsia in ticks collected from deployed military service areas.

DESCRIPTION: Development of this assay is an extremely high priority to the Department of Defense, allowing rapid determination of infected ticks and timely implementation of prevention and control programs to minimize the impact of the diseases in deployed US forces.
REQUIREMENT: To quickly and accurately determine whether ticks collected during military deployments are infected with TBEV, CCHFV, and/or Rickettsia, the three most militarily-relevant tick-borne diseases, to minimize the impact of the disease on our operational capabilities and minimize medical evacuation and lost-duty time. Rapid identification of the pathogen should occur as far-forward as possible, and the testing methodology must be easily portable, shelf-stable, and cost effective.

A. Desired Capability/Concept of the Final Product: We envision a rapid multiplexed detection hand-held assay capable of simultaneously determining whether ticks are infected with TBEV, CCHFV, and/or Rickettsia. The assay shall detect a large range of serotypes and strains of TBEV, CCHFV, and/or Rickettsia. The assay shall be rapid (<30 min), one- or two-step format, and stable (storage at 35C for 2 years). The assay shall be at least 80% as specific and at least 80% as sensitive compared to current gold-standard assays (real time PCR and/or ELISA) and shall require a small (<100ul) sample volume. The assay shall be soldier-friendly (i.e., easy to operate), inexpensive, portable, use heat-stable reagents, and have no special storage requirements.

B. Technical Risk: There is a degree of technical risk involved in this project. There are currently no existing assays that meet the requirements outlined in this proposal. The candidate contractor is expected to use innovation and in-house expertise to develop a prototype that meets the needs of the Department of Defense.

C. Access to Government Facilities and Supplies: Reagents, positive-control materials, infected ticks, etc, to support this project may be available from the Walter Reed Army Institute of Research (WRAIR) and United States Army

Medical Research Institute for Infectious Diseases(USAMRIID). The candidate contractor should coordinate with the Contracting Officer Representative (COR) for any support required from WRAIR.

PHASE I: Selected contractor shall determine the feasibility of the concept by developing a prototype diagnostic assay that has the potential to meet the broad needs discussed in this topic. For phase I we envision a rapid detection hand-held assay capable of detecting at least one serotype/isolate of TBEV, CCHFV, and Rickettsia. Contractor shall conduct an initial laboratory evaluation of the prototype device with inactivated pathogens and provide a written report to COR. By the conclusion of Phase I, the selected contractor shall provide a single lot of 100 prototype assays to the COR.Selected contractor must coordinate with the COR for access to required reagents from the WRAIR or USAMRIID. The degree to which the prototype assay meets the desired capability outlined above will be evaluated at a 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 provides at least 80% sensitivity and at least 80% specificity when compared to current gold standard assays for each TBEV, CCHFV, and Rickettsia. Once sensitivity/specificity requirements have been met, the selected contractor shall conduct comprehensive laboratory evaluation of the assay performance characteristics (sensitivity, specificity, positive and negative predictive value, accuracy and reliability) and initial field testing.

The selected contractor shall also conduct stability testing of the device in Phase II. Stability testing should be conducted under both real-time and accelerated (attempt to force the product to fail under a broad range of temperature and humidity conditions and extremes) conditions.

The WRAIR or USAMRIID may provide support to facilitate the test and evaluation of the developed device. The selected contractor shall coordinate in advance with the COR for any support required from the WRAIR or USAMRIID.

It is envisioned to have a universal hand-held device; therefore the Phase II proposal must include a detailed description of the strains and serotypes (of the pathogen) that will be used for the evaluation.

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 or USAMMRIID.

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 applications: 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 TBEV, CCHFV, and Rickettsia are endemic. We envision that the contractor that develops the TBEV, CCHFV, and Rickettsia 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.

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KEYWORDS: CCH, TBE, Ricketssia, detection, assay, next- generation, field-deployable, diagnostic, device.

A09-157 TITLE: Portable Device for Noninvasive Quantization of Post Traumatic Stress Disorder (PTSD) and Mild Traumatic Brain Injury (M-TBI)

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: Capitalize on recent advances in functional neuroimaging and EEG noise reduction to develop and demonstrate a novel portable multi-modal neuroimaging device with spatial and temporal resolution sufficient to detect subtle patterns of brain activity associated with mild Traumatic Brain Injury (mTBI) and Post Traumatic Stress Disorder (PTSD).

DESCRIPTION: The American Academy of Neurology has established diagnostic criteria for Traumatic Brain Injury based upon gross behavioral and affective symptoms. These symptoms are difficult to observe in many battlefield situations and provide only superficial descriptions of what may be a distinctly complicated injury. Mild Traumatic Brain Injury (mTBI) is uniquely difficult to diagnose due to the often delayed and subtle presentation of symptoms. Additionally, many of the symptoms that present for mTBI are also common to other battlefield related neuropsychological conditions, such as Acute Stress Disorder and Post Traumatic Stress Disorder (PTSD). Data gathered before and soon after a battlefield related insult can be used to train computer models to provide detail and differentiation to the diagnosis of mTBI or other related neuropathologies.

Research using both established measures of neural activity, such as electroencephalogram (EEG), and newer, more advanced functional neuroimaging techniques, including functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI), and functional Near Infrared Spectroscopy (fNRIS), have shown promise in the detection of mTBI. For example, alternations in theta wave activity as measured using EEG have been associated with varying degrees of head trauma. Studies using fNIRS have shown decrements in cerebral oxygenation following mild head injury. Recent research using DTI has demonstrated diffuse axonal damage in individuals with mild head injury. However promising these methods may be, research has consistently shown that a large number of individuals with mTBI show no signs of trauma by neuroimaging, despite the presence of cognitive and/or physical symptoms suggestive of mild head injury. Thus each of these neuroimaging methods alone are not yet sufficient to provide a reliable diagnosis of mTBI.

Chronic stress conditions, including PTSD, are associated with amygdala hyperactivity, hippocampus hypotrophy, and pre-frontal cortex (PFC) hyporesponsivity. Although the limbic structures are too deep for traditional electrophysiological imaging, magnetoencephalographic (MEG) and modified electroencephalographic (EEG) techniques have shown some success in detecting alterations in brain activity within the amygdala and insula in people with PTSD. In addition, many areas to which limbic structures project, such as the PFC, demonstrate altered function linked to PTSD in recent research and can be more easily accessed by EEG and fNIRS. Functional imaging techniques (such as fNIRS) that infer blood-oxygen level may provide an array of measurements that contribute to the assessment of PTSD and related disorders. Anxiety related alterations in respiration, heart rate, and blood pressure may aid in differentiation between these disorders and other potential causes of dysfunction through changes in the blood oxygenation profile.

Recent work has shown that combining the temporal resolution of EEG with the localized detection of hemodynamic changes (usually provided by fMRI) significantly enhances the diagnostic sensitivity for anxiety disorders of either method alone. Based on evidence from previous research, combining EEG with fNIRS (which also provides localized detection of brain blood oxygenation) may provide far greater sensitivity for the differentiation of mTBI and PTSD from normal cognitive states. This novel combination of imaging modalities could provide a portable, low-cost, noninvasive, rapid screening tool for use in detection of mTBI and PTSD soon after battlefield insult and for use in determining the readiness of a soldier to return to duty.

To model multifactorial conditions like PTSD or mTBI, a weighted metrology that is derived from a large volume of data that includes measurements from pre and post injury is required to gain the fidelity and resolution for the model to suggest a diagnosis. To gather this volume of data, we require a portable, inexpensive device that can be utilized near the forward edge of the battle area, be transported by vehicle to remote sites for decentralized operation, and provide data comparable to legacy neuro-imaging devices. This new device must provide images or other data streams with sufficient temporal and spatial resolution to differentiate subclinical indicators of mTBI and PTSD from pre-trauma states. It will combine electrophysiological data collection and functional (or hemodynamic) data collection into one array, so that the disparate data streams can be temporally matched with specific evocative stimuli, thus enhancing diagnostic modeling efforts. This device shall: use non-invasive techniques to gather the data; provide functional, spatial, and electrophysiological data; collect data from medically relevant areas of the cortex; limit the preparation required of the subject/patient; allow sufficient freedom-of-movement for the subject/patient to conduct limited physical/cognitive tasks. Developing the models to diagnose PTSD and mTBI is not the focus of this project; rather, the focus is to build the device that will provide the developmental platform and the data for in-house researchers to derive diagnostic models. The minimum deliverable will consist of the multi-modal sensor array, control interface, data conveyance from patient through to the central processing unit, control software, and data discrimination software.

PHASE I: Deliverables for Phase I shall be: 1) an analysis that will identify two or more imaging approaches for integration into array, 2) a conceptual design for the proposed sensor array assembly, 3) a report of an investigation of the effect(s), if any, of simultaneous use of the proposed multiple sensor modalities in close proximity to each other, 4) an analysis that will identify obstacles to data collection fidelity and suggest strategies to overcome those obstacles, 5) a conceptual design for control interface and associated hardware, 6) pseudo-code for control and data-discrimination software, 7) preliminary research of potential market area, 8) an outline of applicable FDA performance requirements and relevant safety regulations, 9) a proposed Gantt chart for prototype testing and production in Phase II.

PHASE II: Deliverable for Phase II shall be one functional, portable, neuroimaging advanced prototype ensemble to include: 1) prototype multi-modal sensor array apparatus, 2) all required hardware for data conveyance from sensor array to storage, 3) control and input/output hardware, 4) associated control and data-discrimination software. Additional requirements for Phase II include: 1) successful demonstration of the operation of the completed device in a relevant environment, 2) a report detailing the validation of data fidelity on control subjects and mTBI/PTSD sufferers using both the prototype and the separate legacy devices it aims to integrate 3) all required documentation to demonstrate regulatory performance compliance for FDA premarket approval, 4) a report detailing a marketing strategy and proposed efforts to secure capital for Low Rate of Initial Production (LRIP).

PHASE III: This imaging ensemble will have both military and civilian applications. While the applications for mTBI and PTSD detection in the military are noted, there is an increasing awareness of the effects of mTBI in the professional sports world as well as in other civilian trauma settings. Phase III will focus on gaining FDA approval for the proposed device and plans for marketing toward sports and occupational health industries. Concurrent with FDA trials and product marketing, Phase III will necessitate the involvement of academia and government medical research institutes to begin data collection on individuals with PTSD and mTBI so modeling software can be trained. Phase III will conclude with the implementation of the LRIP plan from Phase II and establishment of the production baseline.

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KEYWORDS: functional neuroimaging, EEG, near infrared spectroscopy, optical brain imaging, diffuse optical imaging, tissue doppler imaging, cognitive assessment

A09-158 TITLE: Development of New Repellent Application Techniques for Military Clothing

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: The topic seeks to develop and evaluate new repellent application technologies for clothing materials, to include military uniform fabrics. The proposed repellent application should demonstrate bite protection against common arthropod vectors and meet other specifications IAW JSOR for Insect/Arthropod Repellent System (June 1987) and the Capability Production Document for Core Soldier System (CSS) (June 2007). The proposed repellent and/or repellent application technology must prove to have no detrimental effect on the physical properties of the textile fabric.

DESCRIPTION: Historically, Disease and Non-Battle Injuries (DNBI), particularly vector-borne diseases, have resulted in more casualties than have combat operations. Vector-borne diseases remain a significant threat in military and humanitarian operations resulting in reductions in manpower, lost duty days, and decreased combat effectiveness. Personal protective measures (PPMs) are the most effective means of protecting soldiers from these threats. The Department of Defensess (DoD) Arthropod Repellent System, when employed properly, protects Soldiers from potential vector-borne disease threats. The system consists of: 1) a permethrin-treated uniform; 2) DEET applied on exposed skin; and 3) proper wear of the military uniform.

Permethrin, a synthetic pyrethroid, is both an insecticide and repellent and approved by the Environmental Protection Agency (EPA) as a clothing treatment. It has been used by the DoD as a uniform treatment for over 12 years. However, development of pyrethroid resistance to several vector species has been recently documented in several countries and the absence of any suitable alternative insecticide class for clothing treatment may undermine our ability to continue to protect service members against vector-borne diseases. Compounding this problem is the reduction of permethrin content that occurs with wear and laundering of IDA Kit treated ACUs (Army Combat Uniform) as well as evidence that the current methods of permethrin application do not work as well or cannot be used on the recently introduced FRACU (Fire Retardant ACU). Since the ACU and FRACU are fairly new introductions into the DoD and Army clothing line, little to no research has been done to investigate new application techniques. However, recent research in other areas of vector control, primarily treatment of bed net materials, has demonstrated some new ways (e.g. nanotechnology) to impregnate textiles.

In addition, anecdotal evidence, evidence from surveys of troops redeploying from theatres of operation, and the rates of vector-borne diseases from recent operations demonstrates that use of personal protective measures, particularly the military topical repellent, is low among service members; therefore, a renewed focus on the more passive aspect of the DoD Arthropod Repellent System is needed.

PHASE I: Selected contractor identifies potential arthropod repellents and investigates processes for application (impregnation) of these repellents to textile materials. Processes can include, but are not limited to; coating, spraying, dipping or tumbling. Contractor should investigate and determine the technical feasibility of potential repellents and processes by producing treated prototypes for small scale testing. Testing on the prototypes should be conducted to determine what effect the application parameters have on the physical properties of the textile material. Things to consider include: 1) the effect of solvent choice and temperature on the textile fibers, 2) the effectiveness against a wide range of arthropod vectors; 3) safety (eventual registration of repellent and/or processes with the EPA); and 4) retention to wear and laundering. Contractor should develop approaches for implementation and conduct limited testing of materials.

PHASE II: Utilizing findings from Phase I, selected contractor further investigates and develops processes for textile impregnation, to include military clothing materials, with an arthropod repellent. Development should include treatment parameters such as dosage rate, curing temperatures and modes for consistent application of the repellent. Contractor should select an application method and parameters, address scale-up challenges and demonstrate technical feasibility. Contractor should establish that product meets performance parameters through larger scale prototype fabrication and experiments that demonstrate the following: 1) bite protection provided against important arthropod vectors, such as mosquitoes, phlebotomine sand flies, and biting midges; 2) persistence of the clothing repellency with wear and laundering; and 3) the effect of the treatment on the physical properties of the material such as strength, color-fastness and hand. Contractor should design experiments to establish performance parameters in accordance with EPA and military requirements. The selected contractor will also conduct testing of physical,chemical, and toxicological properties of the selected repellent and impregnated fabrics in accordance with EPA requirements. The selected contractor provides sufficient material for independent testing at government laboratories and facilities. The government labs or facilities, such as Natick, will provide feedback to the contractor regarding the efficacy of the formulation in repelling arthropods.

PHASE III /DUAL USE APPLICATIONS: This SBIR has strong commercialization potential. Currently, there is an increased interest in the private-sector in public health pesticides (repellents) to combat and prevent arthropod-borne diseases, such as West Nile Virus. Currently, the military has evidence that our DoD Arthropod Repellent System is vulnerable due to 1) low levels of compliance with the standard military topical repellent, 2) evidence of arthropod resistance to permethrin, the military clothing repellent, and 3) failure of permethrin to work as well on new military clothing materials (FRACUs). This leaves troops vulnerable to arthropod-borne disease. Therefore, the military has an interest in a clothing repellent application technique that has superior efficacy and duration. Such an application technique would be of great interest to the commercial sector as well given the increased interest in outdoor clothing that has been factory impregnated with a repellent, such as the Insect Shield Repellent Apparel products. A primary requirement under Phase III is to demonstrate ability and technical feasibility of large scale production and further validate the compatibility of the active ingredient and application process with military clothing materials. The contractor should develop a commercialization plan to include partnering and collaboration with a company with experience in production, transition, and marketing of such products for consumer and/or usage. Transition of the product for military usage should include establishment of a product-based Integrated Product Team (IPT) in collaboration with the U.S. Army Medical Material Development Agency (USAMMDA) so that a product can be integrated into the requirements document for the Core Soldier System (CSS). Phase III would also include working with the Natick Soldier Center and the Armed Forces Pest Management Board to ensure product meets military standards.

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KEYWORDS: arthropod, repellent, bite protection, textiles

A09-159 TITLE: Apparatus for Non-Invasive Estimation of Arterial Carbon-Dioxide Content for Ventilation of Combat Casualties

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: The objective is to develop a device of accurately and noninvasively estimating the partial pressure of carbon dioxide of arterial blood in a combat casualty.

DESCRIPTION: Endotracheal intubation and mechanical ventilation are lifesaving interventions for combat casualties who are unable to breath for themselves, due to head injury, blood loss, lung failure, or other injuries.

However, combat medics do not currently have a method for mechanically ventilating patients, and rely instead on manual bag-valve ventilation. Extensive prehospital data from large civilian studies has shown that errors in ventilation (too much or too little) are common when the manual bag-valve method is performed. The same studies have shown that such errors are associated with increased mortality in patients with traumatic brain injury, since these patients are exquisitely sensitive to the effects of carbon dioxide on brain blood flow, and to inadequate oxygen levels. Military data confirm that such errors are common in patients arriving to a Combat Support Hospital.

In order to solve this problem, two things are needed. One is a replacement for the manual bag-valve device, i.e. a small prehospital mechanical ventilator. One such device is under development.

However, equally important is a method of measuring the blood carbon dioxide content (partial pressure, PCO2), to ensure that ventilation is performed in a manner which achieves a normal PCO2 (neither too much nor too little). Normally, this requires an invasive arterial blood gas analysis, which is not possible in the prehospital setting.

Thus, there is a need for a noninvasive estimate of PCO2 that can be performed in combat casualties. No such device exists. The PCO2 cannot be predicted based on the exhaled CO2 level (ETCO2) alone, because of the many factors which affect the excretion of CO2 into the lungs with each exhaled breath.

Such technology for noninvasive PCO2 estimation may include advanced algorithms for analysis of the ETCO2-exhaled volume waveform, the ETCO2 waveform, the transcutaneous CO2 level, a combination of the above and other vital signs, or some novel measurement technology. It should be suitable for use in combat casualties who have hypovolemic shock, acute lung injury, massive resuscitation, and other factors which alter the ETCO2-PCO2 relationship.

The ultimate goal is a device which can be incorporated into field systems in order to provide feedback to the medic on whether the ventilator is maintaining the PCO2 within the target range. In other words, a "new vital sign" is sought which would tell the medic whether ventilation is adequate, too little, or too much.

PHASE I: Demonstrate the feasibility of and develop a design for a noninvasive device for estimation of the arterial PCO2 level of a combat casualty. This effort may require identification of a suitable human patient database to support algorithm development, if an empiric algorithm is proposed.

PHASE II: Develop, demonstrate, and evaluate a prototype noninvasive device for estimation of the arterial PC O2 level of a combat casualty. Such a device should be suitable for testing in future human patient clinical trials, with little or no modification. Human testing is not required under this phase. However, if clinical trials are not performed during Phase II, then preclinical trials in an intubated, mechanically ventilated large-animal model will be expected. The requirements for this phase include accuracy (with respect to an arterial blood gas sample) of +/-2.5 mmHg; and a refresh rate of once every minute. These parameters arise from a requirement to maintain the PCO2 within a target range known to relate to mortality in head-injured patients, and a requirement to support closed-loop control of a mechanical ventilator.

PHASE III: The envisioned end state for this research is an FDA-approved device which is lightweight, rugged, and field-deployable aboard front-line ambulances and medical helicopters. The target size is 2 x 3 x 6 cm (approx.), and the target weight is less than one pound. (In particular, the device must be suitable for incorporation into Decision Support and/or Closed-Loop Control systems, in conjunction with a mechanical ventilator, in order to provide precise control of a patientï¿½s PCO2 within a target range. Demonstration of such integration is not required, but the device must be employ non-proprietary outputs to permit such integration.) The device is expected to have similar military and civilian uses. The product should be developed with the intent of commercializing it for use in civilian aeromedical evacuation helicopters, Emergency Departments and Intensive Care Units as a component of critical-care monitoring. The commercialization potential is expected to be very good. In support of the FDA approval process, clinical trials are expected during Phase III.

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KEYWORDS: carbon dioxide, blood gases, traumatic brain injury, hemorrhagic shock, acute lung injury, mechanical ventilation, combat casualty care

A09-160 TITLE: Innovative Microclimate Cooling Technology

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop the next generation Microclimate Cooling Technology through innovations in materials and design concepts to mitigate Soldier heat stress.

DESCRIPTION: An innovative cooling technology is required to address Soldier requirements. Extreme heat, highly insulative personal protective equipment, and high levels of physiological exertion create a significant risk of heat related injury and degrade physical and cognitive performance. Current ice-based cooling technologies are unacceptable due to system weight and bulk and the difficulty of obtaining ice in the field. Currently available personal cooling technologies do not address the needs of the Soldier during dismounted operations. This is especially true when personnel are required to wear body armor and/or chemical protective clothing.

An innovative microclimate cooling technology should enable a seamless and unobtrusive integration of cooling, without impacting the protective capabilities and operations of Soldier clothing and individual equipment. The intent is to drive current all in one package designs into smaller individual component envelopes utilizing advanced technology and system configuration concepts. This would allow for a more streamlined profile when integrated into a Soldiers clothing and individual equipment.

The microclimate cooling technology should have the following performance requirements:

-System Volume: 130 in3 (threshold); 110 in3 (objective) with 2.5 inch maximum depth. System volume includes the cooling device and power source.
-Thermal Performance: Provide a minimum of 150 watts in a 95F/74% relative humidity environment.
-System Weight: 6.0 lb. System weight includes the cooling device and power source.
-Duration: Minimum of four hours continuous.
-Power: Military standard or commercial batteries only, 12 Volt DC nominal.
-Cooling system operation must be orientation insensitive.
-Noise: Not to exceed 60 dBa when measured at one meter

Note: Technologies that require a refrigerator, freezer, or air conditioned space to recharge coolant media will not be considered.

Proposals should provide sufficient detail on how the requirements will be met. An analysis showing how the proposed technology will meet the cooling requirement must be included. For example, if a liquid circulating system is being proposed, then the analysis should indicate the flow rate and temperature of the fluid being provided by the cooling system to the cooling garment.

PHASE I: Research, develop and propose a design with the potential of realizing the goals in the description above. Identify components (e.g. market survey) and/or develop technical specifications for components that, when integrated, will meet the performance goals. Conduct necessary investigation on the design and performance of the components to demonstrate the feasibility and practicality of the proposed system design for maximum efficiency, including mitigation of risks associated with factors limiting system performance. Deliver monthly progress reports as well as a final report documenting the research and development efforts, identifying any technical challenges that may cause a performance parameter(s) not to be met. Also include a detailed description of the proposed prototype/technology.

PHASE II: Develop the technology identified in Phase I. Fabricate and demonstrate one prototype (including cooling device and power source). The prototype must be capable of demonstrating the performance goals stated in the description above in a relevant environment. Deliver monthly progress reports and a final report documenting the design specifications, performance characterization and any recommendations for future development.

PHASE III: A microclimate cooling system meeting the performance requirements outlined in this effort would be applicable to military and civilian user groups. Civilian first responders, such as local and state police forces (including bomb squads) who train and/or operate in environments requiring the use of ballistic protective equipment would realize heat relief benefits, extending mission durations and enhancing thermal comfort. Military personnel, particularly users wearing body armor and chemical protective clothing, would also gain the same heat relief advantages with the outcome of this effort. Heat stress is a real concern and current commercial cooling systems are not acceptable.

REFERENCES:
1. Updated Assessment of Microclimate Cooling Options for the Individual Soldier, Nellis, et al, February 2003

KEYWORDS: Microclimate Cooling, Heat Stress, Chemical Protective Clothing

A09-161 TITLE: <u>Novel In-Line Water Purification System</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design and build a Soldier-portable, hydration system compatible, in-line water purification system to support Soldier On-The-Move Hydration.

DESCRIPTION: The Army has a need for a water purification technology that can be embedded into Soldier on the move hydration systems with performance that is superior to individual disinfection technologies currently fielded by the US Army. This need has been identified by the US Army Infantry Center in the Individual Water Treatment Device (IWTD) Capabilities Production Document as well as in the Soldier as a System Initial Capabilities Document (Saas ICD)

The individual water treatment methodologies currently employed by the US Army are based on chemical disinfection by either iodine tablets or Chlor-Floc tablets. Both of these treatment methods require an extended treatment time that puts the Soldier at risk of dehydration and result in drinking water with poor palatability and odor, thereby reducing the chance of the Soldier drinking the water when it is available. In addition both of these treatment methods demonstrate marginal efficacy in the reduction of viruses, bacteria and cysts in cold water and/or EPA Type II water. Finally, neither of these treatments address the concern of surface water sources that are contaminated by TICs/TIMs which can adversely affect Soldier performance. In short, these methods provide marginal protection and fail to satisfy the emergency hydration needs of the Soldier.

Several market surveys have been performed to determine whether commercial manufacturers have suitable technologies to address this Warfighter need. The results have shown that there are many commercial approaches addressing hydration on the individual level. Unfortunately these solutions are specifically designed to satisfy the needs of the civilian traveler and/or outdoors person, and do not consider the unique challenges particular to forward deployed Soldiers relying on found water sources for survival. Commercial solutions include in-line water filtration devices, ultraviolet lights, alternate chemical disinfection, hand pumps, or a combination of these technologies.

Each solution has unique challenges making them independently unsuitable for the Warfighters needs. The current in-line water filtration devices have limited flow rates and limited functionality over the Basic Cold/Hot operational temperature range. UV lights burden the Soldier with power requirements, are ineffective in turbid water, are incompatible with MOLLE hydration systems, and endanger the Soldier by providing a visual signature. Chemical disinfectants are similar to the current solution and suffer from the same inability as iodine and Chlor-Floc to reduce turbidity, TICs/TIMs, and increase palatability. Commercial hand pumps can be effective but are limited by cube, weight and lack of on the move capability. A well designed military solution to individual water purification would also satisfy the capability gaps found in the Commercial water purification market.

The goal of this project is to develop a water purification technology that provides the individual Soldier with the capability of generating clean, safe, palatable drinking water from non-salt indigenous water sources. The solution should address the deficiencies found in the commercial market. It will function hands-free when integrated with current and developmental personal hydration systems, and must purify water in a manner superior to the currently fielded disinfection tablets and equal to the current state-of-the-art hand-held water purification devices. The production technology should be lightweight, compact, operate hands-free, and remove turbidity, bacteria, viruses and protozoan cysts from fresh water sources. This purification system will provide the dismounted Soldier with the capability to be self sustaining during continuous operations for up to 72 hours without receiving replenishment of supplies. The technology must be capable of disinfecting and/or removing microbiological contaminants per NSF/USACHPPM Protocol P-248 for Microbiological Purifiers. This Protocol demands bacterial removal to 6 logs, protozoan cyst removal to 3 logs, and viral removal to 4 logs in both EPA Type I and Type II waters. The purification system must produce at least 135 liters of potable water before maintenance or the need for replacement parts. The system must reduce turbidity (below 1 ntu), have a flow rate of not less than 200 milliliters per minute at no greater than 3 psi, and weigh less than 18 ounces. The system must be able to survive a 4 foot drop to concrete, a 6 foot drop to concrete while encased in a hydration system carrier, and 300 lbs dynamic and static compression.

In addition to the threshold requirements, consideration will be given toward the removal of Toxic Industrial Chemicals (TICs), Toxic Industrial Materials (TIMs), and Chemical Warfare Agents (CWAs) identified in the military drinking water standards (TB Med 577) to below the levels stated based on initial concentrations prescribed in WATER SUPPLY MANAGEMENT PROGRAM PROJECT NO. 31-EC-04TL (available on request).

PHASE I: Conduct analytical and experimental laboratory studies demonstrating proof of concept. Demonstrate feasibility for the purification of drinking water in a laboratory environment with an expected level of maturity of TRL 4.

PHASE II: Demonstrate and refine a conceptual prototype system for selection meeting a lightweight and compact design. Conduct sub-component design, fabrication, and testing for critical components and subassemblies providing an assessment of reduction levels. Produce minimum 5 prototype systems for evaluation in a relevant environment to analyze durability and efficiency of reduction levels in a simulated operational environment. Testing in a simulated environment should be robust enough in this phase to assess performance, capability, durability, and capacity of water purification devices to the TRL 5.

PHASE III: Successful technologies developed under this effort will be transitioned for military application by Project Manager Soldier Equipment as a part of a pre-planned product improvement to the Soldier on-the-move hydration system. The final system will be evaluated in a simulated relevant operational environment to meet a TRL 6 or higher. Potential commercial applications include recreational and occupational safety, as well as law enforcement, first responders, and disaster relief.

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4. Capabilities Production Document (CPD) for the Individual Water Treatment Device (IWTD), US Army Infantry Center, Ft. Benning.

5. Capabilities Production Document for the Nuclear, Biological, and Chemical Personal Hydration System (NEPHS), US Army Chemical School, Ft. Leonard Wood

6. US Marine Corp Statement of Need for the Individual Water Purification Device (IWPS).

7. USACHPPM/NSF Protocol P248

8. USACHPPM Technical Bulletin Medical 577

9. USACHPPM Technical Guide 230

10. Iodine Tablets fact sheets, http://www.potableaqua.com/potable-aqua-faq/

11. Chlor-Floc fact Sheet, http://chppm-www.apgea.army.mil/WPD/WPDShare/136/AddInfo_ChlorFloc.pdf

KEYWORDS: water, P248, Filtration, hydration, Soldier system, Purification, hydration system

A09-162 TITLE: Thermoelectric Subsytem for Self-Powered Equipment

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, 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 thermoelectric power generation technology to provide sufficient power to operate man-portable field kitchen equipment to eliminate the need for an external generator.

DESCRIPTION: Current field-kitchen appliances eg., ovens, griddles, kettles, and sinks are heated by combusting JP-8 fuel. The electric power required to burn the JP-8 is supplied from a separate JP-8 fired generator. The internal combustion engine based generators are only 20-25% efficient and have a mean time between failures of 500 hrs [10]. The reliability of the entire kitchen and its appliances are dependent on the reliability of a single internal combustion engine generator. The generators are heavy, loud, and require one hour of maintenance for every 20 hours of use. Thermoelectric generators (TEGs) by contrast are silent, lightweight; they have no moving parts, and they require no maintenance themselves. Durability and longevity of thermoelectric generators are demonstrated by Pioneer 10, which was equipped with a radioisotope-heated thermoelectric generator. Pioneer 10 was launched in 1972 and continued communication with Earth until January 2003 (almost 31 years).

Advances in thermoelectric power generation and pressure to reduce global energy consumption have spurred interest in utilizing TEGs for power generation. Their efficiency, typically <5% is not currently high enough for primary power [5]. However, TEGS are excellent for cogeneration where overall system efficiency is more important than the generators electrical efficiency. For example, a Selfpowered Tray Ration Heater has been developed with commercially available Bismuth Telluride modules [1]. The hot side of the modules is heated by a JP8 burner and the cold side is cooled with boiling water. Since the purpose of this appliance is to boil water, thermoelectrics are an ideal application. Similarly, a Selfpowered Space Heater has been developed with Lead Telluride modules that are cooled by air used to heat a tent [2]. Other thermoelectric applications are intended to convert waste heat to electricity. For example, universities, automobile manufacturers and thermoelectric research companies are working together on the Freedom Car program to develop a thermoelectric generator that yields electricity from the high temperature exhaust [3][8].   Depending on the temperature regime of the application, various thermoelectric materials such as Bismuth Telluride, Lead Telluride, Skutterudites, Silicon Germanium, and TAGS can be applied to generate power [4][12].

For this SBIR topic, neither hot water nor warm air is a useful product. Griddles, ovens, and skillets, are typically 375F. Therefore, the primary objective of this topic is to develop a hot plate, heated partially or completely by a TEG that provides electric power with a cold side temperature of 375F and a hot side temperature as high as possible to maximize efficiency and minimize the number of modules required to provide power for a burner, control system and battery. The primary challenge will be to reject heat so that the hot plate temperature is 375F +10F with a maximum heat output of 30K BTU/hour. One method of accomplishing this is with a heat pipe, to transfer heat from the cold side of the module to the hot plate at a controlled temperature. Current equipment [6] requires approximately 100W of electric power to operate the JP8 burner and controls, but research is underway [7] to improve heat transfer efficiency and operate appliances with minimum electrical power, <50W. Therefore the TEG must be able to produce a minimum of 50W (100W desired) and 24 volts, within 5 minutes of burner ignition; and not substantially increase the weight of the appliance (<80 pounds for two-man lift). The TEG (including heat exchangers, power conditioning, controls, and battery) must be producible at under $5,000. For both phase I and II the use of a modulating gas burner to prove feasibility is desired, the use or development of a JP8 burner is also acceptable. Concepts that utilize, as a main approach, high efficiency (>10%) TEG materials in an exhaust flue will be considered responsive, but less desirable. Other technologies that can be integrated within the system to generate electricity will also be considered.

PHASE I: Research, develop, and design an innovative concept with detailed and quantified arguments for feasibility. Comparisons should be made to present-day technology, as well as other similar applications. Cost, high reliability, maintainability, and size are important characteristics that shall be featured in the design. Demonstrate (i.e., not just perform a paper study) the feasibility and practicality of thermoelectric power generation integrated into an appliance. Evaluation will be based on the proposing teams core competency of the technology proposed, their level of effort, their ability to commercialize, and their potential for commercialization of the specific technologies. Deliver a final report specifying how full-scale performance and control requirements will be met in Phase II. The report shall also detail the conceptual design, performance modeling, safety, risk mitigation measures, MANPRINT, and estimated production costs.

PHASE II: Refine the concept and fabricate two prototype systems that meet all temperature, heat and power output, control, and efficiency requirements and are sufficiently mature for technical and operational testing, limited field-testing, demonstration, and display. Define manufacturability issues related to full scale production of the prototype system for military and commercial application. Identify safety and human factors and provide user manuals and training to support testing of the equipment.

PHASE III: The initial use for this technology will be to power military kitchen appliances without the need for an external generator. Recovery of waste heat is applicable to both military and civilian automotive applications and may be applied to building Selfpowered water and space heating systems. When used in cogeneration, thermoelectrics are able to use otherwise wasted heat. Technological advances in thermoelectric manufacturing and material technology may readily benefit various systems which produce heat as a byproduct.

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KEYWORDS: thermoelectric, combustion, generator, self-powered, man-portable

A09-163 TITLE: Automated Data Recording Technology for Assessing Parachute Performance and Use

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop reliable and accurate data recording technology for assessing parachute performance and use during airdrop missions.

DESCRIPTION: It is necessary to track performance and usage parameters of both personnel and cargo parachute systems throughout airdrop operations. Information relating to parachute performance (such as opening shock force, descent rate, etc.) during an individual airdrop mission is valuable in cases of incidents resulting in a parachute failure or even an injury or fatality. In current accident investigation cases, no consistent means of data collection exists whereby parameters such as deployment time, location, altitude and opening shock force can be made available. In addition, information regarding parachute usage and packing frequency is currently hand recorded in a logbook and used to determine maintenance and repacking schedules. This places additional labor requirements on the soldier and introduces room for human error and safety risk if the system is left in service too long. This represents the current state of the art in parachute data recording along with eyewitness accounts concerning incidents if available. As such, there is room for technical innovation to simplify and improve the data recording process.

In response to this capability gap it is desired to develop an innovative automatic data recording device whereby both routine performance and usage parameters critical to an accident investigation can be reliably collected upon each parachute deployment. This desired system would serve as a retro-fit compatible with existing cargo and personnel airdrop systems. The airdrop systems main components, harness and container, should serve as the database key. This will allow for flexibility between main and reserve parachutes. Data recording could be initiated upon parachute deployment by means of stress/strain inducement and capture time, location, altitude and opening shock. Pressure sensing technology can be used to record altitude while integration with GPS technology can record both location and provide a real-time stamp for data logging. Additionally, the system should provide an interface to allow the parachute rigger to record packing information including a method to record the parachute riggers identification (i.e. signature via smart card (CAC) technology or some other electronic means). The proposed system should maintain the current state of the art and capture all current logbook information for the life of the parachute system as well as the parachute performance data. The proposed system will also require a degree of innovation in regards to size reduction of the data recording technologies needed to capture this information.

The proposed system must also be compatible with both static line and Military Freefall Parachute systems and record the following information for each jump which is broken down into primary and secondary needs. Primary needs represent data collected without significant modifications to the parachute system. Secondary needs represent data collection requiring additional equipment development which will need to be attached to parachute system or jumper:

Static Line:
Primary Needs
- Parachute Packed By and Date and Serial Number
- Reserve Packed By and Date and Serial Number
- Jumper Identification
- Aircraft Type
- Date of Jump
- DZ Location
- Parachute Harness Type
- Equipment Configuration
- Jumper Weight
- Jump Master Inspection By

Secondary Needs
- Opening Shock profile
- Rate of Descent profile
- Altitude

Freefall:
Primary Needs
- Altitude at Exit- User Input
- Altitude at Opening- User Input
- Main Parachute Type and Serial Number
- Reserve Parachute Type and Serial Number
- Parachute Harness Type and Serial Number
- Automatic Activation Device Type and Serial Number
- Oxygen Equipment Type and Serial Number
- Parachute Packed By and Date
- Reserve Packed By and Date
- Jumper Identification
- Aircraft Type
- Aircraft Speed- User Input
- Date of Jump
- DZ Location
- Equipment Configuration
- Altimeter Type and Setting
- Jump Master Inspection By

Secondary Needs
- Altitude at Exit- Automated
- Altitude at Opening- Automated
- Measured Opening Shock

It should be noted that any proposed system should not alter the current safety characteristics of any parachute system and will have minimal size and weight characteristics. Weight will be restricted to no more than 2 lbs with a preference of less than 1 lb. Dimensions of the data recorded will be limited to no more than 2 in. x 4 in. x 3/4 in assuming that the package will be located in the pack tray this size will maximize the pack volume. The end system will also be waterproof to a depth of 5 meters for a duration of at least 30 minutes. Passive data collection methods are preferred. Once the data has been recorded, the system should have the ability to be easily read by means of a barcode/Radio Frequency Identification (RFID) scanning technology. Radio Frequency Identification (RFID) scanning technology is commonly used to easily transfer information for logistical purposes. As such this technology may also be applied to easily read recorded data via a scanning method. The data should be easily transferred directly into spreadsheet format, preferably MS Excel or Access. System maintenance will also be kept to a minimum requiring service at a rate of no more than every 3-4 years. Battery power requirements will also be kept to a minimum and will also require replacement no more than every 3-4 years. Power supply must be small, maintain all data and be attached to the harness or container as the over database key. The end product should replicate and enhance the functionality of current logbooks and records kept for all parachute systems and eliminate the labor intensiveness and error propensity inherent in the current method of manual data recording. The automatic data tracking will also provide a more accurate assessment of system performance. This will aid ongoing product improvement while reducing the need for specialized testing since training and operational data will be readily available.

PHASE I: Investigate, research, and design a comprehensive data collection system to record all the parachute performance parameters and data as outlined in the Description section. The system shall incorporate all necessary sensors (e.g., stress/strain), GPS and RFID technology required to collect the required data and provide an interface that allow parachute riggers to record packing information and ID. Develop a means by which this data can be easily read afterwards by way of RFID scanning technology. Components will be assembled in a breadboard design and demonstrated to work together in an integrated system that, at a minimum, validates the primary needs level of functionality.

PHASE II: Develop, demonstrate, and validate a prototype data collection system, which will be retrofitted onto an existing parachute system. The data collection system will be shown to function properly following numerous test drops during which all desired data parameters will be collected, stored and read following landing. Independent measurement of the data parameters will either confirm or contradict the accuracy of the data collection system. Required Phase II deliverables will include five fully functional prototypes.

PHASE III: The data collection system outlined in this effort would be applicable in both the military and civilian parachuting arenas. Use of a reliable data collection system in civilian sport parachuting would provide the same benefit for accident investigations as in military use. Demonstration of successful use of such a system first by the military will promote the marketability of this type of system in the commercial arena.

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4. Special Tools List (RPSTL) For Ancillary Equipment for Military Free Fall System

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KEYWORDS: Radio Frequency Identification (RFID), Permanent Memory, Virtual/Automated Log Book, Malfunction Review, Inventory Control, Configuration Control , Maintenance and Usage Database

A09-164 TITLE: Lightweight Bomb Suit Face Shield

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

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

OBJECTIVE: Design and build a lightweight bomb suit face shield for Explosive Ordnance Disposal (EOD) Soldiers and combat engineers to reduce combat load (weight and volume) and improve mobility during missions. The face shield design shall have the capability to attach to all sizes of the Advanced Combat Helmet (ACH). The currently fielded Advanced Bomb Suit (ABS) face shield is a very large and relatively heavy design that only mounts to the oversized ABS helmet shell. The current ABS face shield design presents both an unnecessary weight burden and reduced range of motion for a smaller sized wearer. It is desirable that the lightweight bomb suit face shield incorporates the least amount of transparent armor materials needed to meet the visual field of view requirements. The lightweight face shield shall meet or exceed the minimum fragmentation protection requirements for the entire face and shall meet the maximum weight threshold requirement.

DESCRIPTION: Design and build a lightweight bomb suit face shield that provides fragmentation protection [V50 test (MIL-STD-662F) at 0 degree obliquity for 17 grain (.22 cal) FSP (MIL-DTL-46593B): V50 = 2600 ft/s (minimum)]. The face shield shall have capability to attach to various sizes of the ACH and shall provide visual field of view comparable with the ABS system. The face shield mounting hardware shall have a robust design with capability for the face shield to flip-up and shall include a locking mechanism to maintain the face shield in the up and down positions. The complete face shield, including mounting hardware, shall have a maximum weight threshold of 3 Lbs. The transparent region of the face shield shall have a maximum thickness of 1 inch and the non-transparent regions shall have a maximum thickness of 0.5 inches. Design considerations shall be made so that the total system weight (face shield and helmet) is distributed such that the system is balanced on the head. The design shall provide a method of defogging the transparent region on the face shield. The transparent region of the face shield shall meet the optical ABS requirements for distortion, transmittance, prismatic deviation, refractive power, abrasion resistance and haze detailed in MIL-DTL-43511D.

PHASE I: Establish the feasibility of a lightweight bomb suit face protection concept that meets the operational requirements stated in the topic objective by conducting research to demonstrate that the approach is scientifically valid and practicable. Mitigate risk by identifying and addressing the most challenging technical hurdles in order to establish viability of the technology or process. Perform proof-of-principle validation in a laboratory environment, and characterize effectiveness through experimentation using ballistic and optical test results on candidate material solutions. Address safety and human factors concerns, and provide credible projections of performance, size, weight, and cost of a system suitable for fielding.

PHASE II: Refine the technology and fabricate advanced prototypes that meet all operational, effectiveness, and reliability requirements. Address manufacturability issues related to full-scale production for military and commercial utilization. Maintain strict attention to safety and human factors. Provide prototype units that are sufficiently mature for technical and operational testing, limited field-testing, demonstration, and display. Provide user manuals and training to support government testing of the equipment.

PHASE III: The initial military application for this technology will be a lightweight bomb suit face protection system for use with fielded bomb disposal suit ensembles. The transition from research to operational capability will most likely result from a partnership or licensing agreement with a manufacturer of bomb suit systems and subsequent military procurement as a commercial or non-developmental item. The civilian law enforcement and first responder market for bomb suit systems and similar products is larger than the military market, and any advances in system weight, efficiency, and ease of use can be marketed to those EOD communities. Beyond bomb suit applications, lightweight face protection technology and concepts may be transferred to develop a new class of battlefield face protection systems for soldier survivability.

REFERENCES:
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3. Detail Specification MIL-DTL-43511D Detail Specification, Face shields, Flyers Helmet, Polycarbonate.

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KEYWORDS: bomb suit, EOD, ABS, ACH, face shield

A09-165 TITLE: Washable Wool Products for Individual Protection

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: The development of novel, low cost treatment that renders wool fabrics machine washable and dryable in a field environment with little to no shrinkage.

DESCRIPTION: Improvised explosive devices (IEDs) are used by enemy agents in Iraq and Afghanistan and they result in more injuries than conventional weapons. In addition to the blast and ballistic effects, they also cause burn injuries which are a significant source of combat related casualties and fatalities. Due to the nature of the operations in Iraqi and Afghan theaters soldier missions involve vehicle based operations on the urban battlefield and ground operations consisting of foot patrols or ground watches which makes them susceptible to the effects of burning vehicles, clothing and equipment. Flame and thermal resistant protective clothing systems are being developed to mitigate these burn related injuries.

Flame resistant wool fabrics show promise for combat clothing applications but historically have been under utilized on the battlefield due to sustainment issues. While the military currently consumes about twenty percent of the domestic wool clip for dress clothing, blankets and socks, many wool-based clothing articles shrink excessively when machine washed and dried or require dry cleaning, which is not practical on the battlefield. New innovative protective fabrics made from wool could be introduced but there is no domestic source for washable wool treatments for fibers and fabrics. For many years the military used wool socks that had been shrink resistant treated off-shore, but a recent Berry amendment change required that all textile processes must be accomplished in the United States regardless of value added to the end product, effectively prohibiting use of off-shore treatments. A shrink resistance treatment would make wool a viable candidate for protective combat clothing and could be used in virtually any application from head to toe including jackets, trousers, underwear, headwear, handwear, and socks.

Traditional textile finishing methods to control shrinkage involve treatments that reduce the profile of, or remove the scales from the wool fiber cuticle. Overseas methods include the use of chlorine-releasing agents such as sodium hypochlorite and sodium salt dichloroisocyanurate. However, these chlorine based agents react with impurities in the wool to form absorbable organic chlorine compounds. In addition, these methods are known to be difficult to control, may decrease fiber strength and result in significant end product variability. Alternative finishing methods to remove or cover wool fiber scales are desired that significantly reduce the fabric shrinkage, do not degrade the fiber strength, maintain or improve the fibers dyeability, reduce the fabrics pilling behavior, and do not significantly result in the loss of other natural wool characteristics. Environmentally friendly processes, such as enzyme-based bio-polishing methods that remove or reduce the profile of wool fiber scales are desired but not required.

PHASE I: The technical feasibility to develop a textile treatment that reduces the shrinkage of wool, when commercially laundered, without detrimentally affecting other wool fiber properties such as strength and flame resistance shall be established. New and innovative methods to develop treatments such as enzyme based bio-polishing treatments that remove wool fiber scales, and/or resin based treatments that cover the fiber scales and other novel treatments for the fiber, wool top, yarn or fabric shall be investigated. The final fabric shall shrink no more than three percent in woven form, no more than five percent in knitted form (AATCC-96 Dimensional Changes in Commercial Laundering of Woven and Knitted Fabrics), shall be safe to wear, comfortable, cost effective, and dyeable using traditional dyeing methods. The treatment shall be durable for the life of the garment. The most effective treatments, methods, and manufacturing processes will be investigated, determined and proposed for Phase II efforts. A report shall be delivered documenting the research and development supporting the effort along with a detailed description of chemicals, biologicals, manufacturing methods and processes, cost benefits, potential domestic manufacturing base, and associated risk for the proposed Phase II effort.

PHASE II: The contractor shall develop, demonstrate and validate a new process or method that reduces wool shrinkage. The contractor shall deliver small quantities of fiber, wool top, yarn, and knit and woven fabrics that demonstrate the performance in accordance with the goals described in Phase I. A report shall be delivered documenting the research and development supporting the effort along with fiber and fabric test methods, test data, and a detailed description and specifications of the novel chemicals and/or biologicals, formulation, performance, methods, associated costs, and manufacturing processes.

PHASE III: A field evaluation may be planned to evaluate the performance and processes of materials developed in Phase II. In Phase III, the contractor may deliver large quantities of shrink resistant wool socks, knit undergarments or combat uniforms that meet all other performance requirements including breaking strength, bursting strength, weight, shade, and color fastness to perspiration, laundering, and light (MIL-C-83429, MIL-C-44436). In addition to military applications, commercial applications include launderable, affordable flame resistant wool fabrics for municipal firefighting, industrial workwear, electrical workers, law enforcement, first responders, urban search and rescue, childrens sleepwear, and foreign military.

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KEYWORDS: Flame resistance, laundering, wool, fabrics, fibers

A09-166 TITLE: One-Time Use Parafoil

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and demonstrate a one-time use parafoil capable of being deployed at up to 18,000 ft MSL and sufficiently robust to safely deliver a 1000 - 1850 lb payload.

DESCRIPTION: Current military ram air gliding parachutes (parafoils) are typically constructed from rip-stop nylon due to its strength, durability, and availability. However, rip-stop nylon is expensive and requires the use of heavy narrow woven fabric tapes to restrain the panels to a shape that allows the parafoil to efficiently glide and be responsive to maneuver controls. The use of heavy tapes increases weight, manufacturing complexity, pack volume, and cost. PM-FSS for cargo aerial delivery is currently fielding precision guided airdrop systems for 2K lb payloads consisting of an Airborne Guidance Unit (AGU) and a parafoil. When used operationally, it is difficult to recover the parafoils and AGUs back to a central location in a timely and efficient manner for redeployment.

Round parachutes and parafoils are used to deliver supplies to ground troops that are not easily and safely accessible by ground. The very nature of where airdrop is conducted makes parachute recovery difficult since they land in inaccessible locations. Currently the return rate for round parachutes is as low as 4% with only 1% being usable. Parafoils are used when high offset and precision is required to reach the intended impact point. Locations requiring parafoils would typically be even more remote and inaccessible than locations where round parachutes are used to deliver supplies. Therefore, it would be difficult to expect a higher rate of return for parafoils than round parachutes. The lower cost of round parachutes compared to parafoils makes it a little more tolerable if a round parachute is only used once.

The two basic problems with re-using parafoils in an operational environment is recovery and material damage. Since the parafoils land in areas inaccessible by ground vehicle the current CONOPS calls for returning airdrop systems via helicopter. Space on helicopters is a premium due to the volume and weight of equipment and personnel that have to be transported. Since the airdrop systems AGU is the more expensive and the smaller of the two components, the parafoil is often not recovered. Second, if parafoils are not expeditiously recovered from the dropzone they can sustain damage from the extreme environmental conditions. Sunlight degrades the structural strength of the material and the wind can drag the parafoil through rough terrain that damages both the parafoil material and lines often beyond economical repair. An AGU can survive in the sun and wind and be recovered and re-used. A parafoil cannot survive in such an environment. If the entire system is left in the elements for any period of time it is likely that the AGU will be the only piece of equipment that can be re-used.

Decisions on which type of system should be used to deliver supplies to a Forward Operating Base (FOB) are based on the threat level (i.e. high threat means the airdrop must be conducted from high altitude, outside most Weapon Engagement Zones). In order to achieve precision accuracy at high altitudes, a parafoil and AGU must be used. A low cost parafoil for the 2K systems would provide an airdrop capability beneficial to both the Air Force (high altitude delivery) and the Army since the FOB would not be accountable for the parafoils and would only be required to recover and transport the AGUs back. The user should not have to be concerned about recovering the parafoil or the logistics involved in returning it to a central location. Parafoils for 2K systems are, on average, 1025 sq ft. When the parafoils are recovered they take up a large volume of space on helicopters and vehicles. That volume could be used for transporting either personnel or other critical equipment.

It is recognized that with a less expensive parafoil the performances characteristics will diminish some; however it is essential the parafoil still be capable of performing the mission requirements under the current CONOPS. It should be capable of being deployed at altitudes of up to 18,000 ft MSL, of carrying between 1000 - 1850 lbs of suspended weight, and landing at 28.5 fps (T) or less (O) with the cargo payload 85% mission capable (T) or greater (O). Deployment may be from fixed wing or rotary wing aircraft. It should deploy without damage and be capable of delivering the payload safely and in working condition. This parafoil is intended for use with cargo systems only and will not be used for personnel. The parafoil should be delivered to the government either pre-packed or be easy to pack by a trained rigger. A one time use parafoil that arrives pre-packed from the manufacturer will relieve receiving units in theater of the burden of parafoil packing in addition to recovery and repair. The parafoils should attach to a payload using standard rigging methods and not require new training for riggers. It should also be compatible with the Armys AGUs, have steering lines that can be controlled by the AGU, and withstand the forces and wear/tear imposed by the AGUs motors. Technical specifications for the 2K parafoil program are available from PM-FSS.

The current cost of 2,000 lb capable Army parafoil is approximately $10,000. PM-FSS would like to minimally reduce the cost to approximately $4,500, which is the cost of a round parachute that has been used for comparably sized payloads for one time use. The $4,500 cost should be considered a threshold of the program, with an objective cost of $2,500 achieved by automated manufacturing and a reduction in material costs. Achievement of the cost goals can be attained by development or use of inexpensive textiles and innovative construction techniques that will produce a ram-air parachute capable of meeting the aforementioned performance requirements. Offerors need to be cognizant of the Berry Amendment, which precludes the Department of Defense from procuring textile or textile end products that are not produced or manufactured in the United States. Therefore, any parachute material or end product must be made in the United States.

PHASE I: Design a concept for a one-time use parafoil. Perform an analysis of current methods used in producing parafoils and produce a conceptual design for a new and innovative parafoil. An important aspect of the work should be to (a) develop or select a parafoil material that will allow "one-time use" without compromising structural strength, and which complies with the Berry Amendment policies and (b) research new manufacturing technology to reduce cost (i.e. automation, etc). Phase I deliverables will include a detailed prototype design and plan for manufacturing and testing a new one-time use parafoil. Material samples are desired, as well as a detailed manufacturing process plan.

PHASE II: Purchase and demonstrate automated or other manufacturing systems/methods to reduce system cost. Manufacture a one time use parafoil using the new manufacturing techniques. Demonstrate the operation of a prototype one-time use parafoil in a field environment. Testing will be conducted using military rigged payloads to ensure all interfaces are standard and withstand opening shock, flight, and landing. Based on the results of all analyses and demonstration results obtained, system design shall be revised to either enhance the performance or reduce the cost, as required. Between 20 and 50 pre-production prototype systems are anticipated to be required as Phase II deliverables. PM-FSS and Natick Soldier RDEC will coordinate testing at locations such as Yuma Proving Grounds, AZ or Eloy, AZ.

TRL: (Technology Readiness Level) TRL Explanation Biomedical TRL Explanation
TRL 6 - System/subsystem model or prototype demonstration in a relevant environment

PHASE III: This technology can be used by a variety of autonomous aerial delivery systems and could be scaled up or down to cover the full range of airdrop weight classes. It could be used for systems as small as sensor emplacement or as large as the 30,000 lb weight class. The one-time use canopy could also be re-designed to a ballistic parachute if desired. It is expected that such military systems could be adapted for civilian (commercial) use, for accurately delivering disaster relief supplies by air to difficult to reach locations, including mountainous terrain.

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6. Additional Q&A from TPOC in response to FAQs.

KEYWORDS: Airdrop, textiles, manufacturing, parachutes, parafoil design

A09-167 TITLE: Biomimetic-based Flame Retardant Materials for Combat Uniforms and Equipment: Coatings/Fibers Developed from Sustainable and Green Processes

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Through environmentally friendly sustainable and green chemistry processes/technologies, develop flame retardant (FR) materials for combat uniforms and/or equipment based on topical treatments or new generation fibers. New materials should be derived from natural products, such as plants, crops or refined extracts to take advantage of their inherent fire resistant properties. New materials should be environmental and human safe (i.e. non-toxic) from production, through exposure to flame, to disposal. The developed materials/treatments should not deleteriously affect the properties required for military applications (breathability, strength, durability, color, weight, etc.).

DESCRIPTION: There is a need for flame retardant materials that are developed from environmentally friendly processes. This need arises from the Armys vision of implementing sustainable and environmentally friendly technologies wherever possible. This emphasis arises from the general public awareness globally on recycling and the impact on human health of chemical substances used in home environments, household products, cars etc. Currently, flame retardant materials on the market are based on halogens and minerals that are classified as harmful/toxic chemicals. Recently Japan has banned the use of Polybrominated Biphenyls (PBBs), hexa-bromodiphenyl ether (HxBDE) and tetrabromodiphenyl ether (TeBDE). Australia has banned the use of brominated PentaBDE and OctaBDE solutions. Additionally, the California Assembly recently voted to ban halogen-based flame retardants in furniture and bedding products. Globally, there is an increased emphasis on discontinuing the use of compounds that are toxic to humans and the environment. The Army must initiate efforts, which keep pace with the changing global focus on environmentally friendly materials.

Nature has shown a remarkable ability to develop plants, crops, and trees that have fire resistant properties. Examples include species of evergreen shrubs, giant sequoias, and varieties of perennial ground covers. Flame retardance is a function of the plants specific characteristics including moisture content, external sap, etc. Biomaterial extracts from plants or other natural sources can provide special fire retardant properties when incorporated into a polymer system. In addition, it has been demonstrated that by using biomimetic technology it is possible to develop a fire retardant system from simple non-toxic processes. The goal of this SBIR is to take the lessons learned from nature and use a biomimetic approach to develop a new generation of environmental and human safe FR coatings or fibers.

PHASE I: Establish the feasibility of a biomimetic approach that results in the synthesis of novel FR materials, which are non-toxic to humans and the environment, from production through combustion to disposal. Identify the most challenging technical hurdles in order to establish viability of this approach. Utilize the developed approach to synthesize FR materials on a small laboratory scale (i.e. less than 5 grams of material), and determine their thermal stability and FR performance in a laboratory environment through established small scale analytical techniques including, but not limited to, Pyrolysis Combustion Flow Calorimetry (PCFC) and Thermo Gravimetric Analysis (TGA). The specific goals for proving the flame retardancy of the material is the following: the onset decomposition temperatures from TGA should be above 400 degrees C and the heat release capacity from PCFC should be below 200 J/g K. Validate non-toxicity of the starting materials, reagents and catalysts used in the small laboratory scale synthesis. To meet requirements for non-toxicity, starting materials and all other reagents used during the production of the novel FR material must meet or be below the toxicity threshold levels as identified by EPA and OSHA. They must not be considered carcinogenic, teratogenic, and/or mutagenic. Phase I should produce an eco/human safe material (less than 5 grams) exhibiting flame/thermal characteristics (measured using small scale analytical techniques) that are comparable or better than the current FR materials and meet all requirements for non-toxicity throughout the production process.

PHASE II: The combustion and decomposition products of the small scale synthesis in Phase I must be studied by pyrolysis Gas Chromatography-Mass Spectrometry (GCMS) and/or Thermo Gravimetric Analysis-Fourier Transform Infrared Spectroscopy (TGA-FTIR) to verify that the evolved gases and the char are non-toxic to humans and the environment, as identified by EPA & OSHA. Refine the technology by demonstrating the ability to scale up the biomimetic approach established in Phase I and produce enough material to coat it onto fabrics or to produce fabrics from fibers made from the material. Characterize FR, burn injury and mechanical properties through established large scale laboratory techniques including, but not limited to, Limited Oxygen Index (LOI), Vertical Flame Test, Thermal Barrier Test Apparatus (TBTA) and Fabric Pull Test. The specific goal for the LOI is self-extinguishing (a minimum value of 28). The flame resistance determined by the vertical flame test (ASTM D-6413) should be as follows: after flame max 2 seconds, after glow max 25 seconds and char length max 4.5 inches. The developed materials/treatments should not deleteriously affect the properties typically required for military applications (breathability, strength, durability, color, weight, etc.) and must be validated as such. Fabric physical attributes (i.e. yarns/inch, weight, shrinking resistance, appearance and smoothness) must meet or exceed minimum threshold values as defined in Table III of GL-PD-07-12. Results from the fabric pull test should meet or exceed the following guidelines (Table III of GL-PD-07-12): breaking strength of 100 pounds minimum and a tearing strength of 4 pound minimum. The air permeability requirement is a minimum of 10 cu.ft./min/sq.ft. The finished fabric must not present an environmental or health hazard and must not produce any ill effects due to prolonged direct skin contact. Furthermore, any finish, coating etc, would require Office of Surgeon General approval before being used by the Army. This approval may require that an acute dermal irritation study and a skin sensitization study be conducted on laboratory animals. If the results of these studies indicate the (item) is not a sensitizer or irritant, a Repeat Insult Patch Test may need to be performed in accordance with the Modified Draize Procedure. The non-toxicity of the production process, combustion/decomposition products and disposal processes of the materials must be validated and meet all requirements as defined in Phase 1. Establish cost-effective manufacturability; identify and address any issues related to full-scale production for military applications. A cost/benefit analysis is required. Phase II deliverables include: a prototype environmental and human safe FR fabric that meets or surpasses the current specifications (GL-PD-07-12) for flame retardancy, durability, sustainability. Additionally, the contractor must provide the Army enough fabric (approximately 10 yards) for a prototype garment to be used on a mannequin for further Army testing (TRL 5).

PHASE III: If the Phase II is successful, the next step in the Phase III transition process is to deliver a cost effective, biomimetic-based fire retardant fabric (approximately 200 yards) to PM-CIE or other appropriate Army customers for prototyping. The new fabric must be developed from simple non-toxic processes. Additionally, the fabric must produce non-toxic combustion products and must generate non-toxic breakdown byproducts throughout its life cycle. Finalize the environmental and human safe FR fabric to meet and/or surpass all current Army specifications for fire retardancy (GL-PD-07-12). The fabric should also meet all other performance requirements typically required for military applications (MIL-DTL-44436).

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KEYWORDS: flame retardant, eco-friendly, biomimetic, green chemistry, FR coatings, FR fibers

A09-168 TITLE: Antimicrobial Coatings for Medical Shelters

TECHNOLOGY AREAS: Materials/Processes, Biomedical, Human Systems

OBJECTIVE: Develop an antimicrobial coating for Combat Surgical Hospitals which will be applied to rigid wall shelter panels and/or integrated into soft shelter liner fabric.

DESCRIPTION: Clean environments are critical to the mission success of Combat Surgical Hospitals (CSH's). This holds true in forward locations, where the US Army Deployable Medical systems (DEPMEDS) deploys both rigid wall and soft wall shelters. Within these shelters, bacteria such as Acinetobacter baumannii and Methicillin-resistant Staphylococcus aureus (MRSA) are difficult to contain and combat. There has been an increase in the number of military patients becoming ill from hospital stays during Operation Iraqi Freedom (OIF) and Operation

Enduring Freedom (OEF). Developing an effective antimicrobial coating that can be applied to both rigid wall shelters and soft walled shelters will significantly reduce the threat.

There are commercially available products but they all have shortcomings which make them unsuitable for a combat environment. Below is a list of products and their shortcomings.

Products	Shortcomings
Alesta	Does not lend itself to applications on walls and is thus limited to being used on medical equipment/devices.
RepelaCOAT	Same as Alesta
Silver Shield	Same as Alesta
Avron46	Appears to be susceptible to easy damage in the field.
Sureshield	Employs the use of Triclosan. Current research indicates Triclosan may lead to central nervous system depression and impaired thyroid function. Also, dioxins may be created either during the manufacturing process and/or with exposure of the chemical to chlorinated water or UV light (both of which can be found in a Combat Surgical Hospital)
Zoonocide	Leeches out of the fabric during washing
AlphaSan	Same as Zoonocide
Anti-fouling paints	Used in the marine industry which prevent the growth of barnacles on the hulls of ships. These paints utilize copper or tin. But, the use of these paints in a closed environment, such as the interior of a shelter, has not been evaluated for human toxicity and will most likely prove to be too dangerous for shelter application. The eco friendly version of anti-fouling paints relies on the creation of a slick surface that marine organisms will not attach to and, hence, would not be applicable for this effort.

There are also a number of coatings that contain metals, cationic surfactants, polycationic polymers, and polyamines. These coatings are effective as antimicrobials, but they are often non-uniform, or cause degradation of other properties. In the case of metals, like silver, copper, and zinc, cost is a major concern. Another solution, such as silver in zeolite, may provide an ideal mix between performance and cost, however there may be issues of efficacy in normal room temperature environments.

To evaluate efficacy, SBIR solution shall be subjected to the three Environmental Protection Agency (EPA) test protocols (Efficacy as a Sanitizer, Residual Self-Sanitizing Activity and Continuous Reduction of Bacterial Contaminants) will are used to evaluate products against the five bacteria (Staphylococcus aureus, Enterobacter aerogenes, Escherichia coli O157:H7, Pseudomonas aeruginosa, and Methicillin-Resistant Staphylococcus aureus (MRSA)) as well as a modified Japan Industrial Standard (JIS) Z 2801, Antimicrobial Articles, Antimicrobial Test Method and Antimicrobial Effect. Although the EPA test protocols and JIS Z 2801 aren't directly applicable to military use, it will be used as a means to compare the efficacy of various coatings under the same conditions. A 2-log reduction in each of the three EPA test protocols and JIS Z 2801 test is required.

Finally, other factors which will be considered are human toxicity and cost. The actual test protocol for toxicity is yet to be determined. Most likely, an OSHA standard will be chosen, but there are competing standards at EPA. More research is required, in consultation with the Army Surgeon Generals Office to determine the most appropriate standard(s). Finally, the projected production cost will be evaluated for each of the technologies. The goal is to develop a coating which is not significantly higher than the cost of interior Chemical Agent Resistant Coating (CARC) paint (approximately $150/gallon).

Based upon current state-of-the-art, the commercial sector has yet to develop a highly effective coating which will inhibit the growth and spread of bacteria and viruses on both rigid wall and soft wall shelters. Although new technologies such as lysozmes impregnated carbon nanotubes or the use of bacteriophages (viruses that infect bacteria) may eventually lead to a practical coating for shelter applications, work has not been done in this arena. The solution from this SBIR will be a coating which can be safely applied to both rigid and soft wall shelters that balances cost, toxicity, and high efficacy rate at room temperature without degrading the properties of the substrate.

PHASE I: The intention of Phase I of the program is to investigate materials and concepts that will provide antibacterial protection while not degrading other properties or becoming toxic to human beings. A trade off between cost, toxicity and efficacy will be required to further develop the ideal coating. For example, applying antibacterial waterborne nanosilver may allow the user to destroy a wider array of microbes, but may be too expensive to be used to paint the inside of all medical rigid wall shelters. In addition, some coatings may be suitable for one application process but not another. For example, applying a germicidal polymer to the surface of a liner material may be accomplished during manufacturing, but not be easily applied to surfaces after they are produced.

During this phase, a detailed analysis of predicted performance of the chosen coatings will be accomplished. Phase I deliverables will include small samples of treated material which will be subjected to the three EPA test protocols, JIS Z 2801, and toxicity testing. A direct comparison of characteristics with a focus on biocide efficacy will be used to choose the most qualified technical approach.

In parallel, USAMMDA will challenge coated samples to other resistant strains of bacteria (e.g., Vancomycin-resistant Staphylococcus aureus, vancomycin-resistant enterococcus, Penicillin-Resistant Enterococcus, Linezolid-Resistant Enterococcus and Acinetobacter baumannii) and viruses (i.e., rhinovirus and various strains of influenza virus, possibly including H5N1 and H1N1).

A 2-log reduction in each of the three EPA test protocols, JIS Z 2801 test, and USAMMDA testing, plus a positive toxicity test will be threshold for proceeding into Phase II.

TRL 4 is expected to proceed into Phase II.

PHASE II: The focus of Phase II will be to develop, fabricate, and test the coating on full scale shelters (rigid and/or soft). Development of the coating chemistry based on the predictive analysis and the small sample testing performed in Phase I will be accomplished early in Phase II. Once the optimized chemistry is developed, full scale liners treated with the coating will be fabricated and a rigid wall shelter will have the coating applied. Testing will be conducted on the full scale shelters and a direct comparison to a standard, fielded system will be accomplished. The test protocol, is currently being developed by the Medical University of South Carolina and the Telemedicine and Advanced Technology Research Center at Fort Detrick. The protocol will compare bio-loading on samples taken from treated and untreated surfaces. A statistically significant reduction in bio-load will be the threshold for proceeding into Phase III.

TRL 5 is expected to proceed into Phase III.

PHASE III: The focus of Phase I and II of this program is to transition this the successful coatings for military application under the auspices of the Army Surgeon Generals Office into DoD specific shelters utilized in Combat Surgical Hospitals such as the Deployable Medical System (DEPMEDS). The coating, once developed will be applied to rigid wall and soft wall shelters, and evaluated in an operational environment to meet TRL 6 or higher. Upon approval, the coating will be applied to rigid and soft wall shelters during depot maintenance and/or, if possible, as field applications. Additionally, this coating could be used in all of the fixed medical facilities throughout DoD.

Also, there are a number of hospital applications outside of the Department of Defense that would benefit from this research. There has been tremendous interest in antimicrobial coating for reducing hospital-acquired infection. According to a study by the Center for Disease Control, approximately 1.7 million persons per year will acquire an infection during their stay in a hospital; of which approximately 100,000 die. Commercialization of a suitable coating would be extremely beneficial.

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KEYWORDS: coatings, medical, hospital, antibacterial, microbial, liner, lysozmes, bacteriophage

A09-169 TITLE: Lightweight, Flexible Ballistic Protection System for Arc Shaped Shelters

TECHNOLOGY AREAS: Human Systems

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

OBJECTIVE: Develop a lightweight, flexible ballistic protection system specifically designed for the unique arc shape of non-traditional frame shelters that provides a level of force protection against small arms and fragmenting munitions.

DESCRIPTION: The US Military is interested in having ballistic protection for forward operating bases; however, there are many circumstances in which standard ballistic protection, like sandbags and concrete barriers, is not available or practical. Resources to construct and/or procure traditional protection may not be available on site. In addition, truly expeditionary shelter complexes, those that are taken down, moved and re-erected often, require ballistic protection that is lightweight, easy to install, and is modular.

Recently, composite ballistic panel systems have been successfully evaluated for use with the standard Army TEMPER frame tents. The current technical challenge with these panels is outfitting them to arc shaped shelters, like the TEMPER Air Supported, while remaining expeditionary. To remain expeditionary, the panels must install quickly, without excessive added components and weight.

Current Protection: The composite ballistic protection panels that are currently being developed and evaluated have shown exceptional performance against the identified threats. These panels integrate well with the TEMPER frame tent. These panels attach to the frame and transfer the weight and blast energy to the frame and ground. These panels are difficult to integrate with the arc shape shelters because there is not a traditional square frame to attach to. For the TEMPER-Air Supported shelter, an innovative solution would be required to integrate these ballistic panels without adding extensive weight and cube to the system, which is a concern for the user. Additionally, entry/exit and set up times are significant obstacles to overcome.

Future Protection: The current state of the art flexible ballistic protection can provide a flexible solution that will contour to the arc shape, but with a reduced level of protection. The solution from this SBIR will optimize four main factors: ballistic protection, flexibility, weight and cube, and cost.

PHASE I: The intention of Phase I of the program is to investigate state of the art flexible ballistic materials and systems that are sufficiently modular enough in their composition to allow for optimizing the design variables. Flexible panels have long been considered too expensive and too heavy for this application. Developments in manufacturing techniques for both the advanced materials and the methods for assembling them into flexible ballistic systems has allowed many of these options to become truly viable candidates. Principle materials to be investigated could include polyethylenes, aramids, and combinations of these, known as ballistic felts. The ideal system will be flexible enough to contour to the arc of the shelters, lightweight enough to be supported by the shelter, with no single component weighing over 112 lbs., and provide the following ballistic protection:

Projectile------------V50 BL(P) at 0-degree Obliquity (ft/s)
2-grain RCC--------4100
4-grain RCC--------3500
16-grain RCC------2500
64-grain RCC------1800

*when tested per ARMY MIL-STD-662F

The selected technology should be mature enough for military use and commercialization at the end of Phase II. The system must be sufficiently ruggedized to meet extreme environmental conditions without degrading ballistic protection; the ballistics test will be done at 160 degrees Fahrenheit and -60 degrees F. The system must also be able to survive overpressure blast testing, as specified by the United Facilities Code 4-01-010-01, DoD Minimum Antiterrorism Standards for Buildings. The panels must not degrade under UV exposure, or absorb water. The ballistic performance of the selected technology must not degrade under flexing during service or storage. The flexible composite panel system should still meet ballistic performance and blast survivability specifications after being folded a minimum of 50 times. Shelter wall deflection under service loads should be no more than 12 inches with panels installed. Additionally, the system must pass flame resistance values of self-extinguishing after 2 seconds, no melt/drip, and no more than 50% consumption when tested per ASTM D6413. Cost target will be less than $25 per square foot. Phase I deliverables will include a predictability model, small-scale samples of panels, and a preliminary system design. The predictability model will confidently estimate the weight and cost of the system based on material composition needed for various levels of protection. The small-scale samples will aid in design and manufacturing analysis. A direct comparison of all these characteristics will be used to choose the most feasible material and system.

MRL 4 should be achieved by the end of Phase I.

PHASE II: The flexible ballistic system developed during Phase I will be developed into a full-scale prototype during Phase II. The prototype system development will include manufacturing the optimized material solution and the hardware necessary to install the system. The optimized system will be integrated into a TEMPER-Air Supported shelter, either by using a lightweight frame or attaching to the airbeams inside the shelter, or possibly a combination of both. All required characteristics of these prototypes will be evaluated, to include weight, cube, and cost. The system will be evaluated for ballistic protection, and will undergo blast overpressure testing for survivability. Installation time, ease of use, and safety will also be evaluated.

MRL 6 should be achieved by the end of Phase II.

PHASE III: No ballistic protection for the arc shaped shelters exists. The focus of Phase I and II will be optimizing and integrating prototypes for this shelter, while Phase III will focus on applying the panels to numerous other shelters. Phase III will also place an emphasis on production methods for the flexible panels and reducing manufacturing costs. These panels will fulfill an objective requirement for Force Provider and provide the users of the TEMPER-Air Supported shelter ballistic protection. Additionally, users of the Alaska Shelter, like the Air Force Expeditionary Medical Support System and Army Medical Department for example, could benefit from outfitting these panels to that shelter with little or no modifications. The use of these panels will extend to any and all services that use the Force Provider package. In addition, flexible panels can be used by Police, Homeland Security, and many others that require quick installation, flexible panels.

MRL 7 should be achieved by the end of Phase III.

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KEYWORDS: armor, ballistic, airbeam, panel, protection, shelter, tent

A09-170 TITLE: Situational Awareness for Ad-hoc Tactical Networks (SAATN)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this project is to develop suitable algorithms and software to address situational awareness needs of ad-hoc groups operating in tactical networks with intermittent connectivity and evolving operational data needs.

DESCRIPTION: Situational Awareness (SA) is a fundamental tactical requirement. Tactical networks differ from enterprise networks in that network bandwidth, latency, connectivity, and composition can be highly variable, unpredictable, and resource constrained. While the need to share data has increased, data rates available to tactical users have not correspondingly increased.

Army experience has shown that appropriate balance of operational capabilities with the management of group memberships, information content, content granularity, data timeliness, and correlation of historical data context is critical to delivering SA content that is actionable and relevant to individual tactical situations at squad, platoon and company level.

A next generation SA application for tactical ad-hoc networks must:

1. Adapt to changing needs during deployment. Tactical needs change and SA applications must be adjusted to learn about new events (e.g. new IED types, vehicle types, critical infrastructure), new users, and express SA outside traditional pre-defined military symbology.

2. SA communities of interest are operationally dynamic as differing units get tasked so the SA application needs to permit user self management in the field so that the sharing of SA is user defined and controlled in real time as events unfold.

3. The quality and military utility of SA information is dependent upon the quality or the degree that one SA information set matches another (synchronized). The user needs to understand if the SA picture is inconsistent among key users. In a resource constrained environment, the synchronization of information and understanding what is not synchronized among many users geographically separated is critical to support tactical operations.

Basic SAATN capabilities are to:

1. Operate without need for reservations or a central control
2. Support extensible, self defining, SA types (assume a minimum of 64 types)
3. Enable ad-hoc group formation (assume 32 groups with 1000 members each)
4 Enable synchronization of SA groups, types of data, geographic area, or any combination of all three.
5. Operate effectively on data links with 10 kb/s maximum and a 70% per link connectivity rate.

Development of a flexible and extensible situational awareness capability suitable to low bandwidth and intermittent communication will enable the Army, Homeland Defense, and other government organizations to operate more effectively in a dynamic real-time environment as operational needs evolve.

PHASE I: Phase I will be a technical analysis and feasibility study to determine an analytical approach to establishing, defining and managing a SAATN capability. The offeror will identify the challenges and technical barriers to a implementing the SAATN capability. This study will provide a detailed technical description of the approach, expected value, and any assumptions. It should also include a plan for measuring and demonstrating the value of the proposed approach.

PHASE II: The scope of the Phase II will be to develop a demonstration of the SAATN proposed in Phase I. This demonstration shall show that the proposed SAATN design can meet expected performance capabilities in conditions representative of Army tactical operations. An appropriate test case will be defined and can be based on either current tactical network systems or a commercial based mobile system that represent the issues of scale, mobility, wireless propagation and lack of fixed infrastructure appropriately.

PHASE III: During this phase, all software development will be complete and delivered along with documentation. In addition documentation that describes the underlying methodologies, approaches, assumptions, capabilities and limitations will be provided.

The end-state demonstrated prototypes being researched within this topic will have dual-use value in commercial and government application. Potential commercial market applications for this innovation include Homeland

Defense, first-responders, and local and Federal government organizations. This technology would also be commercially viable to news and information services, or social networking applications desiring to minimize bandwidth dependency.

The vendor is responsible for marketing its demonstrated SAATN capability for further development and maturation for potential Post-Phase II transition and integration opportunities including actual military Programs of Record and any dual-use applications to other government and industry business areas.

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KEYWORDS: Wireless, multicast, messaging, SA, Situational Awareness

A09-171 TITLE: Scalable Discrete Event Simulations of Asynchronous Dynamic Systems on Massively Parallel Multi-Core Computers for MANET

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this project is to enable the execution of large-scale (10,000s of communicating nodes), high fidelity, mobile, tactical (primarily wireless) network models in a parallel computing environment, where each computing node is a multi-core processor. The project should develop enabling algorithms and associated software tools to address:

-Scalable parallel discrete event simulation (PDES) of asynchronous dynamic systems.
- Integration of PDES software into network simulator (MANET)
-The integration of these models into Network interdisciplinary Computing Environment (NiCE) which uses Extensible Data Model Format (XDMF).

DESCRIPTION: Mobile Ad hoc NETwork (MANET) are becoming increasingly popular for a wide class of military and civilian applications. Advances in hardware design, and associated rapid growth in communication devices are very attractive for instantaneous deployment of 1000s of secure, reliable, and asynchronous communication nodes in complex and/or hostile environments for both for military and civilian applications. However, to field the large-scale networks with confidence, high fidelity modeling and simulation approaches are essential to evaluate performance of emerging tactical network systems. High fidelity modeling and simulation of MANETs includes accurate modeling of entire protocol stack, real time traffic models, realistic mobility models; physics based propagation models, etc.

Over the last decade, a number of parallel discrete event simulation (PDES) algorithms are developed and implemented on parallel and/or distributed computing architectures. Some of these algorithms are very promising for addressing typical small-scale MANET applications. Similar to advances in communication hardware designs, emerging computing architectures consists of several thousands of processors with multiple cores on each processor. Implementation of existing PEDS algorithms on these computing architectures poses new questions on algorithmic efficiency and scalability. For example, large-scale network simulations are required to adapt to dynamically changing hostile scenarios including addition/subtraction of a number of large-scale communication nodes during run time. This requires dynamic load balancing, that is to distribute load on each processor dynamically during run time including effective memory usage on each processor for parallel efficiency of PDES in which some events may be supporting high fidelity models.

PHASE I: Phase I will be a technical analysis and feasibility study to determine an appropriate approach that will produce a set of tool(s) and or methods that will meet the objectives stated above. The offeror will identify the challenges and technical barriers to enabling large-scale, high fidelity, tactical network modeling in an HPC environment, characterization of the risk and complexity and approaches to addressing these. The study will provide a detailed technical description of the approach, expected value, and any assumptions. It should also include a plan for measuring and demonstrating the value of the approach.

PHASE II: The scope of the Phase II will be to develop a demonstration of the tools and approach proposed in Phase I. This demonstration shall show an approximately 10x (1000s of nodes) improvement over current wireless modeling capability while retaining all of the fidelity (full protocol stack) of current models. An appropriate test case will be defined and can be based on either current tactical network systems or a commercial based mobile system that represents the issues of scale, mobility, wireless propagation and lack of fixed infrastructure appropriately. The expected test site is the Army Research Laboratorys Mobile Network Modeling Institute (MNMI).

PHASE III: During this phase, all software tools will be complete and delivered along with documentation. In addition documentation that describes the underlying methodologies, approaches, assumptions, capabilities and limitations will be provided. The tools will be demonstrated in a tactical mobile network modeling that will be scaled to 10,000s of nodes each modeled in high fidelity.

The end-state demonstrated prototypes being researched within this topic will have dual-use value in commercial and government application. Potential commercial market applications for this innovation include Homeland Defense, first-responders, and local and Federal government organizations. Other potential commercial markets include large scale wireless system vendors that provide services such as 3G, Wi-Fi and others. The vendor is responsible for marketing its demonstrated tools and methods for further development and maturation for potential Post-Phase II transition and integration opportunities including actual military Programs of Record and any dual-use applications to other government and industry business areas.

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KEYWORDS: M&S, Modeling & simulation, parallel computing, HPC, multicore

A09-172 TITLE: <u>Enterprise Logistics Data Mining & Integration Expert System</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: To develop a decision making tool to manage assets throughout the army fleet of ground vehicles. This effort will demonstrate a simulated prototype system that provides real-time decision support to fleet managers, operators, and commanders. It will be based on predicting anomolies, patterns, and trends using data mining of structured and unstructured datasets such as maintenance records, field reports, supply records, vehicle bus data, sensor data, and environmental data.

DESCRIPTION: Future Army Fleet Management Systems, such as, Global Combat Service Support Army (GCSS-A), Logistics Modernization Program (LMP), and the Logistics Information Warehouse (LIW) do not have autonomous data mining capabilities. A lack of automatic fault and anomaly detection capabilities in these systems needs to be enhanced through innovative research.
These are some of the current army databases with brief functional descriptions. While all of these current databases provide their intended functions that they were designed for, there seems to be certain limitations as regards to providing proactive maintenance type information to prevent breakdowns.
OSMIS - is used to predict part purchases for army systems. It tracks operating and support information, but it does not track failure rates or failure modes.

ILAP - is used for requisition, maintenance and accounting. It is a web-based management information program, but it a supply database, not a readiness database.

LIDB - is the central databank for supply and transport information. It provides visibility of requisitions and shipments as they proceed through the logistics pipeline, but the failure mode information is vague and does not identify root causes.

PBUSE - provides the means to manage and track equipment, but it tracks end items only and not the individual components

AEPS - is primarily a logistics web information portal. It provides timely and useful logistics information identifying supply chain deficiencies, but not component deficiencies.

EDA - archives the daily non mission capable (NMC) equipment reports. It identifies all the parts ordered to return systems to mission capable status, but EDA failure rates are solely based on calendar time and it does not contain any engineering failure information.

An effective Enterprise Intelligence System can provide proactive maintenance to enhance the abilities for the detection of remaining useful vehicle life using various data sources, such as, fault codes and operating parameters throughout Army ground fleet vehicles. This can be accomplished by using data mining techniques to discover meaningful anomalies and potential root causes of failure. The current manual process of annotating/detecting faults and dispatching operations can be automated for better efficiency for GCSS-A and other systems. Some enterprise-level intelligence system challenges include consistency, reliability and accuracy in developing diagnostic trends along with determining the amount of diagnostic data that is needed to isolate recurring conditions. The toolset will integrate the vehicle bus / sensor / maintenance type datasets that can currently be collected on Army Ground Vehicles. Access to this data will be provided by the project manager of this SBIR. In the event that data from Army systems is not available, the project manager will utilize professional linkages such as TARDEC""s National Automotive Center to obtain a suitable substitute commercial truck fleet as a test case.

The system will be hosted on an enterprise server type system connected to federated data sources. Automation and Text Data Mining techniques shall be heavily considered in the design of the system. The system will be able to take the vehicle maintenance data and integrate it with information from multiple existing logistics management sources (structured and unstructured), and provide outputs concerning vehicle health and assessment for a fleet-wide aggregate of vehicles. This will allow commanders to make educated decisions concerning the status of the fleet and allow for more efficient mission planning.

PHASE I: The phase I report shall provide a feasibility study that will determine the scientific, technical, and commercial merit of the system. The phase I report shall include the DoDAF Operational View 1 (OV-1) and a detailed description of a real-time expert system to include definition of the required data inputs and planned outputs of the system. The report shall also contain an analysis of the available vehicle bus / sensor, maintenance, supply, field, user and environmental data to identify data gaps. This integration would capture "condition indicators" or "features" in the datasets when they are recorded which will help in detecting trends, patterns, and diagnosing future failures. The report shall provide an analysis of the current Army logistics and supply databases to include, but not be limited to the Integrated Logistics Analysis Program, Logistics Information Warehouse, Standard Depot System, Commodity Command Standard System, and Operating and Support Management Information System. The report shall identify gaps in the current record keeping strategies, supply records, and root cause analysis. A data analysis plan will be developed to create a path to developing diagnostic, prognostic, and any trending or analysis algorithms for the expert system.

PHASE II: Phase II will provide Phase I lessons learned to PEO CS&CSS for possible impacts on logistics management efforts to include transformation into efforts such as Logistics Modernization Program (LMP). Phase II deliverable to government should include the design, build, and demonstration of a prototype expert system. The demonstration shall show the improvements to the Logistics Management Systems to illustrate capabilities, such as, real-time data driven decisions to turn vehicle diagnostic data into a repair part request and the ability to track the assets after ordering.

The system shall also include a fleet management capability to include the selection of best fit vehicles based on readiness to satisfy the intended mission. The demonstration shall also include the creation of Fleet Readiness Reports. The system shall have the ability to prioritize repairs based on the diagnostic information gathered, the difficulty of the repair, and the availability of the required parts.

The demonstration should also include vehicles based on statistical sample sizes on a given platform to assist the Army in evaluating their usage and collect enough datasets to provide significant fault signatures to optimize maintenance tasks with the resulting engineering, logistics and cost drivers information.

PHASE III: Phase III should provide a production capable module style expert system including data mining that can integrate into the existing Army Logistics Enterprise at the unit level . The benefit of this would be to eliminate stovepipe logistics management systems that are fielded at the unit level. The system should also be commercialized to be used by commercial fleet managers across the trucking community.

The resulting deliverable to the government will be the enterprise expert system final report detailing algorithms, source code, and configuration required to develop and implement the prototype.

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KEYWORDS: Expert Systems, CBM, Asset Management, Reasoning, Knowledge based Systems, Fleet Management, mission planning, asset tracking, trending, text mining, unstructured text, diagnostic, vehicle health monitoring.

A09-173 TITLE: Smart Sensor Network for Platform Structural Health Monitoring

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Design and develop a real-time health monitoring system that can observe the condition of structural components on Army bridging platforms and notify a remote observer of decreased structural integrity.

DESCRIPTION: The geographic scope of current Army operations in Iraq and Afghanistan has posed a great number of gap crossing situations. Many bridges that were designed to be used in a rapid deployment and temporary circumstance have begun to fill the role of semi-permanent bridges. These bridges are experiencing a high number of crossings with only periodic visual inspections being performed. Presently, there is no system in place that automatically records the number of vehicle crossings, predicts the remaining life of the bridge, or communicates that information to decision makers. With the current operations tempo in Iraq, these bridges are subjected to a number of crossings, traffic, and loads that are well beyond design characteristics. This level of stress and fatigue gives light to the problem of unanticipated failure that could have catastrophic results if failure occurs during a crossing. The challenge lies in ultimately creating a universal structural health monitoring system that can be incorporated on multiple bridge platforms. The system development would be marked by milestones, the first being installed on the Line of Communication Bridge (LOCB) by Fiscal Year (FY) 2010. Other milestones would include the integration on the Armored Vehicle Launch Bridge (AVLB) in FY 2011, the Rapidly Emplaced Bridging System (REBS) in FY 2012, and the Composite Joint Assault Bridge (CJAB) in FY 2013. The system should be able to scan and assess the overall integrity and remaining life of the bridge, its critical components, and notify inspection teams with critical data that can safeguard against bridge failures. The monitoring system will also provide a benefit in that inspection teams will be able to spend less time on each bridge, allowing for more efficient patrols and less exposure time of personnel to hostile situations.

PHASE I: In Phase I, a feasibility study will be conducted to determine the trade-offs between a universal health monitoring system versus a bridge specific monitoring system. Also, a feasibility study will be conducted on incorporating system monitoring sensors on the LOCB, embedding them on this new platform design, and identifying reliable health assessment algorithms. This study will also include the size, weight, and power limitations of the sensor system. This study shall address a plan to acquire or generate power on unpowered bridge systems. The study will include computing requirements for the sensor network and a total cost comparison between alternative network designs. The results of the study will be detailed in a final report.

PHASE II: Phase II will aim to develop the technology and design an acceptable prototype sensor network and health assessment algorithm based off of the findings in Phase I. The first bridge system to incorporate the health monitoring system shall be the LOCB, with the aim of integrating and testing on additional bridge systems. The prototype shall be self-sustaining and require minimal maintenance over an extended period of time. Minimal maintenance means that components shall not require replacement more frequently than regular system maintenance intervals. The sensor network shall be delivered, installed, and tested at a Government test facility to quantify improvement and system impacts. Testing will simulate structural degradation and report on how the health monitoring system responds. The results of the testing, along with detailed fabrication and integration plans, will be included in a final report.

PHASE III: Phase III will involve a transition of the technology as we work with PM Bridging to deploy several health monitoring systems on LOC bridges, to be used in a continuously running demonstration and operational assessment. The results will aid the Army in evaluating the systems use and effectiveness in identifying bridges that require maintenance before grave conditions present themselves. The information provided from these deployed systems shall also help optimize inspection procedures, as well as demonstrate the challenges involved with integrating the health monitoring system on additional bridge systems. Civilian engineering will also benefit from the proposed research for use on public infrastructure such as highway and railway bridges, where real-time structural health assessment can increase safety and avert catastrophic failures that result in loss of life.

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KEYWORDS: Bridging, Structural, Health, Monitoring, Sensors, Network

A09-174 TITLE: <u>Personal Protective Equipment-Integrated Restraints for Blast Mitigating Seats</u>

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The objective of this SBIR is to design and develop a Personal Protection Equipment (PPE)-integrated restraint system for blast mitigating seats. The final product would be seat restraints integrated into PPE such as the currently fielded Interceptor Body Armor (IBA) or equivalent and a quick-release mechanism on the blast mitigating troop seat to allow for faster attachment/detachment to the vehicle which will improve crew survivability.

DESCRIPTION: Seat belts and gunners restraint systems, when used properly, reduce the loss of life and help reduce the severity of injuries. Integrating seat restraints into the body armor or outer jacket of the soldiers normal combat uniform and attach/release easily to the blast mitigating seat, would allow for greater ability to ingress and egress the vehicle effectively and more quickly. This concept will make it easier or automatic for the user to wear their seat restraints to be better protected in a vehicle crash or blast event.

PHASE I: Conduct a subjective and objective ingress/egress study involving fully-equipped representative operators in several different models of vehicles. An investigation of blast resistant quick release mechanisms shall be conducted to determine feasibility of attachment methods. Evaluate current and future PPE for restraint ease of integration. Deliverable: Presentation of results and final report based on the findings. To be eligible for Phase II, development of an innovative and feasible design solution that meets required standards should be in place. PPE-integrated seat restraint system concept(s) should be proposed as a path forward.

PHASE II: Investigation/evaluation of system concept(s), downselect to the best concept according to set parameters such as performance-no crew injury as per NATO STANAG 4569 and NATO HFM-090, comfort-address soldier complaints as to ease of mobility, range of motion, etc. while wearing restraints over uniforms and currently fielded IBA or equivalent, safety-FMVSS 208/214/210, etc. The system should be easily integrated into any troop seat in a broad range of Army vehicles and allow for rapid attachment/detachment. Simulation of proposed PPE-integrated seat restraint system versus existing seat restraint system for a selected vehicle. Prototype fabrication and laboratory experimentation of proposed system. Demonstration of prototype in relevant environment with fully-equipped user representatives. Deliverable: A prototype PPE-integrated seat restraint system, final presentation, and report establishing the restraint system as the optimal choice for commercialization.

PHASE III: Military application(s): Rapid- or long-term fielding of new advanced PPE-integrated seat restraint system into any ground vehicle system and next generation body armor with appropriate upgrades in the seating area. Application of new restraint system or concept in various aircraft or watercraft is also a possibility.

To commercialize the PPE-integrated seat restraint system, automotive racing vehicles or hydroplane racing boats, etc, along with currently-worn racing suits, could be coordinated to take advantage of this technology.

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KEYWORDS: Interceptor Body Armor (IBA), troop seat, Integrated, blast mitigating, seat, restraints, protection, ingress, egress, seat belts

A09-175 TITLE: Development of Silicon Based Lithium-ion Battery Technology

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: To improve the electrochemical properties of silicon film anode in lithium batteries through development and advances in composition and modifying the morphology of anode active materials.

DESCRIPTION: Chemical batteries have been used as electric energy storage devices for many years. With the revival of interest in electric transportation to support military mission and civilian applications, great effort has been put into the research and development of high-performance chemical batteries. Until recently, however, the battery performance has been far from meeting the requirements of the vehicle application. One of the major problems is the very limited amount of energy stored per unit weight (specific energy). Compared with conventional petroleum and internal-combustion-engine-based systems, far less energy is stored in a practical onboard battery, resulting in limited operation time. Electrochemically formed Li-Si alloys have as high as 4200mAh/g theoretical capacity, much higher than that of carbonaceous material, which is promising for high energy lithium ion battery application. However, the silicon anode suffers from a large volume change during charge-discharge leading to cracking and pulverization of the silicon particles. The dramatic volumetric variations, ~300%, upon discharge/charge and poor electronic conductivity hindered its application.

A number of studies were performed to improve the silicon based anodes. One approach to enhancing the cycle life of the Si-based thick film electrode is to combine Si with a highly conductive secondary material to form a composite. Other approaches include silicon nano-wire to circumvent these issues as they can accommodate large strain without pulverization, provide good electronic contact and conduction, and display short lithium insertion distances.

There is a need for further study to improve silicon based electrochemical properties, reduce volumetric changes during the charge-discharge cycle, and/or further verification and modification of existing improvements. By modifying silicon anode morphology, particle size, and nano-composites, better cycle life can be expected.

PHASE I: Conduct research to investigate and evaluate feasibility design concepts to demonstrate the enhanced cycle life of lithium ion batteries with high capacity silicon based anodes. Phase I will address the modification of new composites designs for silicon based anodes with improved electrochemical properties. An improvement of battery capacity is anticipated as compared to that of lithium ion batteries with carbonaceous based anodes. A research study in the form of a report is expected from phase I deliverables.

PHASE II: This phase will cover the development and demonstration of cylindrical or prismatic cells with improved silicon based anode active materials. The cycle life of the cylindrical and prismatic cells shall be more than 500 cycles while the silicon based anode should demonstrate specific capacity of more than 1500Ah/kg. Delivery shall include a small multicell demonstrator battery using manufactured cells with silicon based anode for lab verification and evaluation.

PHASE III: Technology developed in this topic could be scaled up for the process of making silicon based anode active materials, which have yet to be mass-produced for commercial and military applications. The results of the development of the improved cycle life and greatly increased specific energy of lithium ion batteries should enable their incorporation into new types of military and commercial equipment. The high energy cells should allow the development of hybrid and electric vehicles, as well as other applications such laptop computers for consumer electronics.

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KEYWORDS: battery, lithium ion, anode, silicon, energy density, hybrid, silent mobility, silent watch

A09-176 TITLE: Flat Panel Shelter-Mountable Phased Array Antenna for DoD Systems of Record

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Develop a low profile antenna that supports high data rate wide bandwidth satellite communications while being hosted on a prime mover operating in motion.

DESCRIPTION: The purpose for the development of this antenna is to allow the new systems currently in development, to operate while moving. The current Global Broadcast System (GBS) Next Generation Receive Terminal (NGRT) is too bulky in weight and size to allow for operations while moving and too labor intensive to emplace for operations while stationary. Integrating this new low profile antenna will allow the crew to operate from a GBS Rugged Battle Management (RBM) laptop. At a minimum, the antenna must support a single broadcast transponder while moving and dual broadcasts while stationary.

A Flat Panel Phased Array Antenna is the preferred technology, however, any new novel antenna design with a reduced footprint from the current NGRT which can provide frequency coverage in the UHF, X, Ka, Ku Band, and the throughput is approximately 23-25 Mbps is desired.

Functional phased array antennas exist in various forms, to include small arrays with switchable elements, partially mechanically and electronically steerable arrays (hybrid systems) and fully electronically steerable arrays. SATCOM on-the-move (OTM) systems need to maximize data throughput while using an antenna with the smallest possible aperture radiating the smallest power necessary in order to limit interference with other systems.

The Communications-Electronics Research, Development, and Engineering Center (CERDEC) has significant interest in considering novel beamforming modules and architectures that substantially reduce the size, weight, and power (SWAP) and cost of flat panel phased array antennas.

Program Manager Navigation Systems is interested in an antenna that can receive and transmit in the UHF, X, Ka, and Ku Bands. Some of the inherent problems with Ka and Ku band mobile SATCOM include large Doppler shifts and frequency uncertainties, vigorous tracking requirements due to high operational shock and vibration as well as blockage, and high attenuation effects due to environmental conditions. The competing requirements with the inherent constraints, has thus far proved too challenging. An innovative approach is needed, requiring a breakthrough on the component and/or system level.

PHASE I: Develop an innovative concept design and model key elements necessary to theoretically meet or exceed the requirements. This design may be unique and unconventional in nature, including, but not limited to, the possible use of metamaterials. The deliverables shall include a feasibility study with performance predictions and an order of magnitude cost estimate.

PHASE II: Based on the work in Phase I, design and test a single prototype antenna. The prototype shall be tested in a relevant environment (not necessarily an operational environment). Cost estimates shall be refined and updated appropriately. Deliverables shall be one prototype with test plans.

PHASE III: Improve upon design and optimize performance for DoD Systems of Record. This technology will have definitive applications across the military, as well as applications for Ku/Ka-band mobile SATCOM satellite news gathering (SNG) and aeronautical broadcasting. Additionally, disaster recovery, emergency medical service and Homeland Security can benefit from deployed voice, data, and video communications.

PM Navigation Systems will plan to transition this technology if successful to an existing Program of Record.

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11. Caption -- Additional information provided by TPOC: Objective Requirements Document.

KEYWORDS: Antenna, Profiler, weather, meteorological, phased array, SATCOM, OTM

A09-177 TITLE: High Off-Boresight Angle Icing Cloud Characterization Probe

TECHNOLOGY AREAS: Air Platform, Electronics

OBJECTIVE: Investigate the development and fabrication of an icing cloud characterization probe, capable of producing reliable readings at high off-boresight angles.

DESCRIPTION: The aeronautical industry uses airborne probes to characterize icing conditions for flight certification purposes by counting and sizing cloud droplets and icing particles. Existing probes have been developed for meteorologists in order to study cloud microphysics. The Objective Helicopter Icing Spray System (OHISS) Cloud Characterization System (CCS) effort has found a significant shortfall in the instrumentation used to characterize natural and artificial clouds for icing certification. The critical parameters are Mean Volumetric Diameter of the droplets and the Liquid Water Content of the cloud. The most trusted instruments used by icing wind tunnels and measurement aircraft are a Forward Scattering Spectrometer Probe (FSSP) and an Optical Array Probe (OAP.) Both are now obsolete (i.e. no longer in production and supported by a company building a competitive product.) The FAA is trying to get other instrument builders to improve confidence in their products by testing them in a common environment (an icing wind tunnel in Italy) and is looking into the development and certification of next generation systems.

The FSSP and OAP both work by using a laser to sample the cloud at known intervals. Each sample contains a distribution of droplets that gets characterized by the instrument in terms of droplet count by size. There are other technologies that do similar characterizations in different ways.

The design of the FSSPs sensing element is highly dependent of the airflow being aligned with the longitudinal axis of the probe. This causes significant difficulties when used in a helicopter platform environment such as the UH-60 CCS platform for OHISS; where fuselage and rotor effects, together with varying paths for different particle sizes make reliable measurements difficult. In addition, measurement can be highly dependent on the mounting location selected on the aircraft.

What is needed is a sensor probe that:
-- can be common to the icing wind tunnels and airborne measurement aircraft
-- produces equivalent results as the FSSP and OAP
-- is highly tolerant of high off-boresight airflow angles
-- is capable of operating stand-alone on battery power and incorporates wireless telemetry technology for data gathering to facilitate installation on multiple aircraft locations, thus reducing the need for aircraft re-wiring.

Presently there are no technical solutions in line with the objectives of this SBIR.

PHASE I: Conduct a feasibility study, research existing hardware/sensing technologies to develop a new probe or sensor design that addresses the issues described above. The study shall determine technical feasibility of developing a probe that produces equivalent results as the FSSP and OAP, its data correlates with instruments used by the FAA and NASA, which is highly tolerant of high off-boresight airflow angles, and incorporates battery power and wireless technology for data gathering.

PHASE II: Develop, demonstrate and validate through modeling and simulation and lab bench prototypes, a practical design implementation and documentation for the proposed solution. Establish and document performance parameter, technical specification, and coordinate for commonality/correlation with the appropriate Government agencies.

PHASE III: Further develop the design and flight test a flight worthy working prototype that implement the approved design solution. Commercialization opportunities may exist with the FAA, NASA, universities, and aircraft manufacturers in general. All can benefit from the technology.

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KEYWORDS: sensors, electronics, icing, probe, cloud, droplet, cloud characterization.

A09-178 TITLE: Development of High Power Lithium-ion Batteries

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: To improve power density and specific power of rechargeable lithium-ion batteries for military ground vehicle or directed energy weapon applications. Improvements will be made through development of new materials, cell design, and advances in existing electrode active materials.

DESCRIPTION: Batteries capable of delivering high-rate power to long-life single-use military applications have remained virtually unchanged for decades. High power rechargeable lithium batteries may apply to a wide variety of single-use military products, including electric EM guns, high power directed energy weapons, mortar-guidance systems, hybrid tactic vehicles, communications, unattended ground sensors, UAVs Land Warrior system, and others. Those cells are finding their ways to civilian applications such as for power tools, as well. Increasingly powerful and sophisticated military and civilian equipment require higher power batteries to function reliably under various conditions. The power sources need high rate capability, low weight, more power per unit volume, no voltage delay even after long storage periods, operability in a wide range of temperatures, long storage life, and safety.

There is a need for a high power density rechargeable lithium battery technology to increase the silent mobility and silent watch capabilities in military applications as well as enhance commercial vehicle capabilities. The high power battery offers a significant reduction in the weight and volume for vehicle battery systems. The present rechargeable lithium battery cells have about 4.7kW/kg specific power for continuous discharge. By the design of new electrode materials and/or modifying existing battery cell design and electrode active materials, an improvement of rechargeable lithium battery power density and specific power can be expected.

PHASE I: Conduct research to investigate and evaluate the feasibility of new design concepts to demonstrate the enhanced power density and specific power of rechargeable lithium batteries. Phase I will address the design and development as well as performance characteristics of the anode materials, and/or cathode material and scalability issues of the material for actual cell build. A research study in the form of a report is expected from phase I deliverables.

PHASE II: This phase will cover the development and demonstration of cells, and multi-cell modules of cylindrical or prismatic cells. The specific energy of the cylindrical and prismatic cells shall be in the range of 42Wh/kg with a specific power of more than 6kW/kg (continuous discharge). Enhanced cell performance and appropriate electronic controls shall be incorporated into the system, based on the results from Phase I. Delivery shall include small multicell demonstrator batteries using manufactured cells off a pilot line for lab verification and evaluation for use as a high power vehicle or directed energy weapon battery.

PHASE III: Technology developed in this topic could be conducted for dual-use commercialization. The results of the development of the improved power density and specific power of lithium ion batteries should enable their incorporation into two types of systems.
A new generation of high-power rechargeable lithium batteries offers flexibility for long-life single-use military applications. This includes the potential for greater shelf life, increased performance, and enhanced product reliability in challenging environmental conditions. It is advised to further evaluate this new technology against existing battery technologies when retrofitting existing military equipment or developing next-generation military products. The high power cells should allow the development of commercial and consumer electric/plug-in hybrid and hybrid vehicles.

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KEYWORDS: battery, power density, lithium ion, rechargable, silent mobility, silent watch, hybrid vehicle

A09-179 TITLE: Phasing Multiple High Power Impulse RF Sources

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: The objective of this effort is to develop methods for phase locking multiple high power impulse radio frequency sources.

DESCRIPTION: High power in impulse Radio Frequency (RF) sources usually equates to high voltage within the system. At the extremes, megavolt pulsed sources may be necessary to achieve the desired peak power making it problematic to eliminate breakdown and corona sufficiently to achieve acceptable radiation from the source. An alternate to this is to use the proven technique of multiple radiating elements, operating at lower voltage levels, which can be placed in an array such that the far field radiation pattern is typical of one unit operating at a much higher voltage. In this way, many of the systems issues of handling extreme voltage levels in an operational environment are mitigated. As an illustrative example, three phased sources operating at 300 kV would have the same far field radiation pattern as a single source operating at 1000 kV while being much easier to implement in a system that would function in a harsh environment. While most impulse RF sources are difficult to control precisely because they involve spark gap switching, there are several parameters that can be manipulated to induce phased discharges. The parameters are:
1. Change of voltage with respect to time, dV/dt.
2. Absolute value of the voltage.
3. Switch gas species.
4. Switch gas pressure.
5. Use of one oscillator as a master oscillator.

If phasing of multiple heads can be achieved reliably and repeatedly, it could enable fielded systems that produce enormous fields at tactically significant distances while requiring modest input voltage levels. The Army is seeking innovative approaches for phase locking multiple high power impulse RF sources.

PHASE I: Phase I would consist of building a multi-head test fixture to examine how to drive the heads independently, how the statistical breakdown time varies with V, dV/dt, gas species, gas pressure, etc, and the requirements for a master oscillator such as polarity, how to get it to trigger first, and how to configure the array so that the elements combined constructively.

PHASE II: Design, build, and test antenna arrays, verify their enhanced performance parameters, verify that they can efficiently converted loss energy into RF energy, and verify that they can meet the size requirements of platforms to be specified later. Address manufacturing issues.

PHASE III: PHASE III DUAL USE APPLICATIONS: Antennas are used in a wide range of military and commercial applications including radars, communications, and directed energy weapons. Other commercial applications for radio frequency and microwave antennas are drying paper, catalyzing chemical reactions, remote sensing, and various medical diagnostic techniques. The main objective of this effort is to develop an antenna array for the Army's directed energy weapon and target discrimination in complex environments programs. This technology would be of use to all the Services as well as the Missile Defense Agency and the Joint Improvised Explosive Device Defeat Office for multiple applications.

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KEYWORDS: impulse antenna, high power microwave, radio frequency, phased array

A09-180 TITLE: High Performance Power Generation for High Altitude Platforms

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

OBJECTIVE: Develop an improved energy production technology suitable for primary power for sustained flight of high altitude platforms.

DESCRIPTION: Long-endurance powered stratospheric flight requires primary power technology that gathers power from the environment, such as photovoltaics. For future versions of high altitude platforms, this will require photovoltaic technology that has higher efficiencies and higher specific power levels than what is presently available, in large-scale arrays. For systems that use direct sunlight, such as photovoltaics, minimum performance requirements are 16% efficiency in the Air Mass Zero (AM0) environment(> 20% preferred), and 1000 watts/kilogram specific power at the cell level. Higher performance for both of these parameters is highly desirable. For specific power measurements, the mass of the cell includes the active components and substrate. Concentrating systems and approaches are not of interest.

Alternate approaches to extracting energy from the high altitude platforms environment are also of interest. This may include approaches leveraging the blackbody radiation from the earth, which is continuously available, or leveraging temperature differences. For technologies that can continuously extract energy from the high altitude platforms environment, thereby reducing or eliminating the need for nighttime energy storage (such as batteries), lower specific power, on the order of tens of watts per kilogram, may be acceptable. Technologies that leverage available 4 to 40 micron energy to enhance the performance of conventional visible-range photovoltaics are also of interest.

Any technology proposed should be scalable to systems on the order of tens to hundreds of kilowatts, and capable of operating independently without maintenance for at least one year at the high altitude platforms flight altitude of 65,000 feet. Fuel-based systems will not be considered. The technology should be capable of functioning even when the high altitude platform has zero net air speed, and should not impose significant drag or thermal loads on the high altitude platform. Photovoltaic costs of under $50/Watt (projected at scale-up) are strongly preferred.

PHASE I: Conduct feasibility studies, technical analysis and simulation, and small-scale proof-of-concept demonstrations, according to proposed innovations and improvements. Initial technical feasibility of the critical functions shall be demonstrated. An initial conceptual approach to incorporating the technology in a high altitude platform shall be developed.

PHASE II: Implement technology assessed in Phase I effort. Phase II effort should include demonstration of an energy generation prototype with capabilities at a significant scale, demonstrating specific power and efficiency performance. For photovoltaic and similar technologies, multiple cells should be built to demonstrate efficiency and specific power. A practical plan to transition the technology to a complete high altitude platform energy generation system shall be developed. A TRL of 4 should be demonstrated.

PHASE III: The contractor shall finalize the technology of the high performance power generation system and begin commercialization of the product. This technology will provide higher efficiencies and higher specific power levels for power generation than what is presently available. This technology can be used for high altitude long endurance platforms such as High Altitude Airship but also be used in commercial applications, e.g., high efficiency photovoltaic cells.High altitude long endurance Unmanned Air Vehicles would also benefit from the small size, weight and power. Space applications such as tactically responsive Space platforms (for example, nanosatellites) would also potentially benefit.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would advance performance of environmentally friendly electrical power generation, with application in a spectrum of areas, in both the government and private sectors. The commercial satellite industry would likely be interested for remote sensing, communications, and other functions.

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KEYWORDS: KEYWORDS: Solar power, solar cell, photovoltaic, thermophotovoltaic, high altitude airship, high altitude UAV, thin films, up-conversion

A09-181 TITLE: Dynamic Formats in Distributed Simulation Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this topic is to take a thorough examination of several new and innovative technologies and generate applications that will better define dynamic and robust formats for distributed simulations. This topic also plans to optimize real-world accuracy and algorithm performance on existing applications such as Constructive Simulations. Currently the visualization of terrain databases include run-time publishing and on-the-fly geometry calculation (also known as procedural geometry), which contrast sharply with the classic distributed training approach of pre-distributing static terrain databases. The Constructive Simulation to be used for experimentation purposes is OneSAF. This is the simulation of choice for many DoD agencies and is representative of applications that require a static pre-built terrain database. Therefore, the overarching objective of this SBIR topic would be to research new innovative emerging methods for modifying a Constructive Simulation such as OneSAF, plus generate other training applications to that will support and interoperate with procedural geometry technologies.

DESCRIPTION: Army programs are seeking greater commonality through efforts such as OneSAF and SE Core. However, these programs are limited in their ability to take full advantage of some new and emerging visualization technologies based upon a continued reliance on static, pre-built terrain databases. For example, highly dynamic terrain skin and feature content are constrained by static, pre-built databases. Certain image generation systems and even broad architectures require compliance with run-time publishing and on-the-fly geometry derivation. Run time publishing involves pushing terrain data onto the network at run time for clients to accept and operate on. On the fly geometry calculation involves using algorithms to convert simpler data (e.g. cleaned source data) into a specialized data on the fly. The static, pre-distributed terrain database architectures of systems like SE Core and OneSAF cannot interoperate with, or take advantage of, these technologies. Redesign of every simulation system to take advantage of these new features would be very expensive and is therefore not an option. Innovative approaches to allowing the incorporation of these features without a major redesign is the goal here. This effort will investigate ways to bridge the gap between static, pre-distributed terrain database systems and architectures / systems that support dynamic formats such as runtime publishing and on-the-fly geometry calculations. A successful solution will extend the current architecture, making the Environment Runtime Component composable by allowing a OneSAF composition (or any other) which supports different sources of terrain services and information. In this manner, current users may continue to use pre-distributed databases or have the option to interoperate with emerging dynamic formats based upon their particular use case and requirements.

PHASE I: Investigate new trends such as mathematical models and software algorithms in dynamic terrain database representations and capture information about leading technologies and concepts. Investigate the correlation between different systems using these technologies and alternatives that could allow pre-distributed databases to correlate with these different representations. Investigate possible performance improvements associated with the use of lean datasets that are updated and derived at run time. Develop a report on the feasibility and cost of implementing a composable terrain representation supporting one or more alternative technologies. Demonstrate the feasibility and practicality of incorporating of this technology into applications / programs such as OneSAF and SE Core programs.

PHASE II: Implement and demonstrate the approaches defined in Phase I for interoperability and correlation between dynamic formats and classic, pre-distributed terrain solutions such as OneSAF or SE Core. Provide a definition for how to make terrain services composable to support pre-distributed or dynamic technologies with minimal impact to existing efforts. The OneSAF program has a process for Co-Developers to implement new code, update documentation and turn over for incorporation into the next OneSAF Baseline. Follow these procedures to ensure that these improvements get incorporated into the OneSAF baseline for the benefit of all users of OneSAF.

PHASE III: Private Sector Commercial Potential/Dual-Use Applications: Investigate commercial applications that can benefit from dynamic, flexible visualization and terrain services. This will include gaming applications, GIS applications, and secondary applications such as Google Earth, and MapQuest. In addition, Army programs such as PEO C3T, PEO EIS, and PEO IEW&S will benefit from this, also, look at ways that OneSAF technologies can support gaming technologies based upon a more flexible / composable terrain representation that can correlate with, and take advantage of, advanced gaming environment representations.

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KEYWORDS: Runtime Publishing, OneSAF, Constructive Simulation, OTF, ERC, Terrain Databases, Procedural Geometry, Interoperability, Composable, Synthetic Natural Environment, CGF

A09-182 TITLE: Terrain Database Correlation and Automated Testing Technologies

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective is to research methodologies and techniques to analyze database content, quality, and correlation across multiple formats and terrain services within the context of different training systems to include modeling & simulation and command & control domains. This effort will provide mechanisms to verify that disparate terrain formats and terrain services are correlated or functionally equivalent based upon varying system functional objectives. The resultant toolsets, algorithms, software techniques and processes will seek to provide high-value information and capabilities about how varying terrain formats, terrain representations, and terrain services will behave together within a system context while minimizing the need for manual fly over correlation testing.

DESCRIPTION: Modeling Simulation efforts such as SE Core Distributed Virtual Environment Development (DVED), Common Database and the Commercial Joint Mapping Tool Kit (CJMTK) for Command & Control are changing the paradigm for how database and dataset (M&S and C2 Play Box) generation and distribution work. This new paradigm seeks minimize specialized database generation capabilities for each individual simulation program, instead providing a central mechanism for database generation or publishing. However, centralized database generation mechanisms or run-time publishing systems leave unanswered the question of how to verify that these capabilities result in functionally correlated subcomponents within a system context. For example, the SE Core DVED program is providing complete database sets built based upon a common specialization of source data for a particular program. However, the disparate database formats must still be compared to each other. In addition, terrain database are only meaningful in a functional context, based upon how the data is used. Thus, it becomes necessary for test capabilities to stretch above raw database content in context-sensitive use cases and services. Similarly run-time published databases may allow common data on the network, but the client-side use of such data may vary in ways that leads to unexpected results. This effort will investigate solutions to (a) self-consistency checks for key formats (e.g. tree on road), (b) comparison between formats where meaningful relationships exist, (c) comparison of derived or functional results (e.g. do application A and B achieve line of sight at the same time), (d) incorporation of program-specific needs or requirements, e.g. specialization of correlation requirements. The capabilities described herewith should be considered in the context of both visual and non-visual data output formats.

PHASE I: Research innovative methods resulting in new trends such as mathematical models and software algorithms for current database generation, run-time publishing, and terrain services technology to identify and capture information about leading automation and correlation concepts. Identify existing Army programs across live, virtual constructive and Command & Control that can use improved terrain database and terrain service correlation and automation capabilities. Investigate solutions to provide low-level (geometric, consistency), functional (service result), and semantic quality, data quality checking based upon tailorable (program-specific) criteria. Propose solutions that minimize the need for manual correlation testing to the extent possible.

PHASE II: Implement and demonstrate the approaches defined in Phase I for interoperability, automation and correlation between terrain data output products like OneSAF, SE Core, CCTT, CJMTK and others. Demonstrate the ability to automate the testing of these terrain products thereby reducing the cost and manpower workload that it currently takes to verify these output products. Develop a prototype software tool that implements a Correlation and Automated Testing Tool. The capability should determine Terrain Database Correlation employing software algorithms and statically analysis resulting in metrics and characteristics that supports interoperability for disparate domains. Evaluate and demonstrate research findings that are consistent and repeatable; generate correlation scenario to determine interoperability in Modeling and Simulation (M&S), Test and Evaluation, Command & Control and Experimentation applications.

PHASE III: Enhance the prototype to make it suitable for transition to modeling and simulation and command and control applications. Develop a fieldable capability for testing and assuring correlation. Military applications may include integration with virtual and constructive simulations used for testing, training and mission rehearsal. Commercial applications may include integration with emergency response or homeland defense training simulations; city/county offices for urban/city development. Furthermore, private sector commercial potential/Dual-Use Applications is to investigate commercial applications that can benefit from improved accuracy in terrain / Geospatial Information System (GIS) data, such as route identification systems (like MapQuest or GPS navigation systems), municipal use of GIS data for utilities or construction planning, game systems, etc.

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KEYWORDS: Correlated terrain, OneSAF, Constructive Simulation, Terrain Databases, Automated testing, Interoperability, Composable, Synthetic Natural Environment, CGF, Command and Control, Dataset, Maps

A09-183 TITLE: Real Time Damage Monitoring of Composite Vehicle Armor Structure Integrity Using Embedded Sensors

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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 a methodology to assess damage in real time to composite vehicle armor structure panel integrity using signals from embedded sensors. This methodology should be usable when the vehicle is in the depot, on field maneuver and in battlefield environment. Develop a system to provide the composite structural integrity information on a display unit on board the vehicle and also be able to monitor remotely. Develop necessary software based on wave propagation in composite armor structure to determine damage to the armor panel when hit by a projectile and during field maneuver where it is subjected to harsh terrain loads, vibrations and shock. Using signals from armor panel embedded sensors, determine damage location on the composite armor panel, damage severity, and impact round identification. Verify and validate the software by controlled laboratory experiments and field tests on intact and damaged prototype composite armor panels instrumented with embedded sensors. Develop the methodology for thin composite panels, thick laminated composite panels and ceramic polymer composite panels.

Develop computer model for optimal sensor configuration and location in the panel. Develop an integrated system consisting of armor panels with embedded sensors, transducers, signal generators, signal analysis, transmitter, receiver and armor health display unit.

DESCRIPTION: Army is interested to know the integrity of the composite vehicle armor structural panels before vehicle deployment to battlefield and during deployment in the battlefield. The health monitoring of the armor structure panels should have the capability for on board vehicle monitoring and for by remote sensing. Before battlefield deployment the vehicle is subjected to extreme vibrations, shock and rough terrain loads. During this period the health of composite armor structure may be monitored continuously or at certain intervals. During deployment in the battlefield the vehicle is exposed to battlefield environment. It is subjected to loads from landmine blast, projectile impacts, and Improvised Explosive Devices (IEDs). During this period the vehicle composite armor structure health will be continuously monitored for determination of damage, location of damage and severity of damage. This information will be provided in the form of a display on board to the vehicle commander and or monitored remotely. Based on damage information the commander can decide to stay in the battlefield or to return to depot for repairs.

Army light weight vehicles are generally made of composite structure with armor sometime is an integral part of the structure and sometime armor is an appliqu on the outside. Generally the composite structure panels are made of thin composite plates. However, they can also be made of thick laminated composite panels or ceramic polymer composite panels depending on the protection level desired. For light weight vehicles the threat levels are from small arms, machine guns and medium caliber guns. Other threats are landmine, and IEDs.

Current Nondestructive Test and Nondestructive Evaluation (NDT/NDE) technology is used to test intact and damaged composite panels in the laboratory and at the depot levels. Depending on the problem NDT/NDE technologies may use mm wave imaging, x-ray imaging, ultrasound scanning, acoustic emission, strain gauges etc. They can detect crack depth and size, voids, fiber damage, delamination, discontinuities, crack location in composite panels by judicious placement of transducers and sensors on composite panels. The NDT/NDE technology is also used in manufacturing defects detection, in civil structures such as concrete slabs crack location, chemical and nuclear plants to monitor pressure vessels, valves, pipes etc.

There is a need to further advance these technologies and develop new methodology for application in the battlefield environment. The new advances should help in real time monitoring of the integrity of composite panels to assess damage from impacts and inform the decision makers on board or at remote location on the severity of the damage. The proposed solution should be capable of detecting and quantifying damage in armor structure panels and accurately predicting the residual strength and remaining life of the structure.

The solution of the problem requires a combined effort of carefully conducted experiments and field tests with appropriate choice of gauges, and development of an accurate software (whether analytical or numerical) to identify features of damage and its extent from measured sensor data. The integrated system may consist of armor panels with embedded sensors, transducers, signal generators, signal analysis, transmitter, receiver and armor health display unit.

This technology if developed successfully may be used on light weight army vehicles and its other potential commercial applications will be in aircraft industry, space vehicles, civil structures, chemical and nuclear plants.

PHASE I: During phase I perform the following tasks on a thin composite panel to demonstrate the feasibility of the methodology. The prototype thin panel should be 12 inch by 18 inch or similar size.
(1) Develop appropriate analytical method or numerical computer model to study wave propagation in undamaged and damaged thin composite panel.
(2) Conduct hammer impact or low velocity impact experiments on thin composite panels embedded with sensors.
(3) Conduct sensor selection study for appropriate plate embedding sensors.
(4) Develop computer model for optimal sensor configuration and sensor location on thin panel. Develop a program to determine panel resonance frequencies based on a tap test.
(5) Verify and validate developed computer models with experimental data on thin panels.
(6) Develop a preliminary system concept layout for damage monitoring in real time using transducers, transmitter, receiver, signal analysis and display unit.

If the contractor performs these tasks satisfactorily and the work looks promising then it will progress into phase II.

PHASE II: During phase II effort carefully conduct tests on thin panels, multi-layered thick composite panels and ceramic polymer composite panels with small arms, machine gun arms, and medium caliber arms ranging from 7.62 mm to 30 mm emphasizing on the appropriate choice of gauges, their location, and distribution. Conduct tests on panels with impact velocity ranging from low to progressively higher till penetration to measure wave propagation histories for nonpenetrated and penetrated panels. Determine optimum embedded sensor grid size to measure flexural and extensional strains.

Extend analytical and computational software capability to identify features of damage and its extent from measured sensor data. Identify the type of threat by evaluating differences in characteristics (shape and magnitude) of the measured strain histories. Evaluate the difference in wave propagation between non-penetrated and penetrated panels. Further extend the software capability to handle thick multi-layered composite panels and ceramic polymer encapsulated composite panels. Develop a general three-dimensional analysis of general multi-layered thick composites accounting for shear deformation and orthotropicity. The software should be able to make an image of the location and extend of damage using data from embedded sensors.

Verify and Validate the software with experimental and impact test data on thin panels, thick panels, and ceramic composite panels.

Develop an integrated system consisting of armor panels with embedded sensors, transducers, signal generators, signal analysis, transmitter, receiver and armor health display unit. Demonstrate its operation by conducting an impact test on a selected panel and monitoring remotely the damage severity and damage location. The sensors and other instrumentations selected should survive in harsh battlefield environment from terrain loads, desert like conditions and very cold regions.

The contractor will determine the limitations and sensitivity of the instrumentation to detect the flaw types and size. The contractor will perform a sensitivity study to determine the effect on armor mechanical properties with the emplacement of sensors and its adverse impact on armor ballistic performance.

PHASE III: The technology developed under this program if successful can be used on the FCS Armor ATO, TWVS ATO, and on various army light weight vehicles including JLTV, MMWV, and MRAP. Other applications of this technology will be in aircraft industries, space program and in civil structures made of composites.

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KEYWORDS: light weight composite vehicles, transient response of composite panels, composite panel impact damage, composite laminates, armor, Strain gauge, ultrasound transducer and sensor, Nondestructive Testing, Nondestructive evaluation

A09-184 TITLE: Innovative Wheel Control Technologies for Mechanical Counter Mine Equipment

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Make subsystem level improvements to US Army Mine Roller equipment. Improvements lead to increasing the rate of advance (clearing speed) while maintaining or improving the Mine Roller effectiveness in the defeat of buried pressure plate and Explosive Threats (ET) to close multiple identified capability gaps.

DESCRIPTION: This effort will involve work on mechanical clearance materiel solutions to support Assured Mobility. The term "Assured Mobility" encompasses those actions and materiel/design solutions that give commanders the ability to deploy, move, and maneuver where and when they desire, without interruption or delay, to achieve the mission.

ETs are currently a major cause of troop casualties and limit Assured Mobility. This SBIR is aimed at improving the rate of advance (clearing speed) while maintaining or improving the Mine Roller effectiveness in the defeat of buried pressure plate and ETs. These improvements are made at the subsystem level of fielded US Army Counter Mine equipment. The improvements can include but are not limited to; predictive, active, or passive roller wheel control and/or suspension components. The technologies are to be developed and integrated into existing US Army counter mine systems.

The solution shall improve the mobility and maneuverability of the host vehicle with the integrated US Army Mine Roller on the platform. The Army is in the continued pursuit of a mobile, lightweight force that is readily transportable yet has increased mission effectiveness. To support the Armys future vision the product of this effort is to develop an optimized lightweight counter mine and counter ET system that is modular, scalable and adaptable to a wide variety of future platforms.

PHASE I: Conduct feasibility studies and develop concepts to determine the expected improvement in the rate of advance. As part of the study, perform analysis and modeling and simulation to characterize improvements as well as mobility improvements, host platform integration issues, system and subsystem integration issues. The rate of advance must be at least 30kph with a desired increase to 100kph with a minimum of a 50% reduction in wheel hop based on the current configuration at 10kph. The reduction in wheel hop is measured by the projection area when the wheel should be in contact with the ground but is not in contact with the ground due to the hop. The hop begins when the roller wheel has less than 80% of the static weight of the roller wheel. After award, the contractor will receive a GFI dynamic simulation model of the Pearson OIF track width roller configuration. The improved performance in speed of advance and effectiveness needs to be balanced against system mobility, survivability, maintainability, and durability impacts and also projected procurement cost.

PHASE II: Develop the technology and design prototypes as necessary to meet the minimum 50% reduction in wheel hop at a rate of advance of at least 30kph with a desired increase to 100kph. Perform detailed design of hardware to include system/subsystem interface, fabrication, and testing in year two. If contractor testing proves stated performance, the final design hardware may undergo mobility and effectiveness testing at a Government chosen test facility to quantify speed and effectiveness improvements and system mobility, survivability, maintainability, and durability impacts near the end of phase II to demonstrate TRL 6.

PHASE III: Commercial applications for this effort include humanitarian de-mining industry. Military application of this technology is applicable fielded US Army Counter mine systems and sub systems. These counter mine systems are integrated onto Route Clearance Vehicles, MRAP FOV, and Medium Tactical Wheeled Vehicles. A prime example of application of SBIR technology would be to integrate to the Pearson Roller system mounted on the Medium Mine Protected Vehicle (MMPV).

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KEYWORDS: Assured Mobility, Counter Mine, Countermine, Active Wheel Control, Passive Wheel Control, Predictive Wheel Control, Suspension, Mine Roller, Engineers School, MMPV, MRAP

A09-185 TITLE: High Pressure Layflat Hoseline

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The Army is intersted in a high pressure (740psi working pressure) 6-inch diameter "lay flat" hoseline for use with fuel and water systems. Current layflat hoselines are rated at 150 psi working. Under this SBIR determine which fibers, when used in hose construction, are most likely to achieve the required working pressure. Investigate and study through methods such as computer simulation and modeling the ideal fiber orientation in the hose to achieve 740 psi. Investigate multiple methods of fabrication and materials selection and determine which ones are most likely to result in a high pressure layflat hose with a durable outer hose surface. Separation of the hose coupling end fitting is a common concern in high pressure hoses of this diameter. Analize end fitting stresses on both the coupling and the hose and determine the ideal fitting configuration and method of attachment to the hose.

DESCRIPTION: A high pressure 6-inch diameter layflat hoseline is the ideal solution for use in Army water and fuel systems that are required to transport bulk fluid over long distances. A hose with layflat characteristics is easy to store, easy to layout and set up, and easy to retrieve. The hosline will have a working pressure of 740psi with a safety factor (working pressure to burst pressure) of 3 to 1. The hose will be layflat so that it can be stored on hose reels. The hose will be light weight and weigh less than 2 lbs per foot. Hose elongation at working pressure will be less than 1%. Hose twist at working pressure shall be less than 1%. The hoseline needs have a durable exterior suitable for use in military applications where it will be deployed over rugged terrain and used in severe environmental conditions such as direct exposure to the sun and elevated temperatures. Several previous efforts have been made to develop a hose that meets these criteria. To date, none of the prototypes hoses have been able to satisfy all of these requirements. Hose elongation approaching 10% and a working pressure in the 500 psi range has been typical in many of the prototype hoses. The type of high strength fiber used to construct the hose jacket and the orientation of the fibers in the jacket are two of the key factors that directly contribute to hose performance in the critical areas of working pressure, elongation, and twist. The thickness and type of material on the outer surface of the hose are key factors in determining hose durability. The purpose of this SBIR is to develop a method to meeting the hose requirements stated above. It will focus on investigating state of the art high strength fibers, determining the ideal fiber orientation in the hose jacket, end fitting connection to the hoseline, and expected durability of outer hoseline surface. Cost will be a determining factor. Ideally, the cost per foot would not exceed $45.

PHASE I: Investigate state of the art high strength fibers and determine which ones could most likely be expected to result in a hoseline that meets the requirements as previously defined. Study and evaluate multiple fiber layout and geometric configurations for hose jacket construction. Conduct computer modeling and simulations on each configuration to determine which on is most likely to result in working pressure of 750 psi with an elongation and twist of less than 1%. Perform analysis, modeling and simulation for end fitting connections to the hoseline. Investigate multiple materials that could be used for the outer hose surface and determine which are most likely to result in successful performance.

PHASE II: Based on the results from phase I, Fabricate a section of 6-inch prototype high pressure layflat hose. The testing conducted during this phase will focus on the following key areas, burst pressure on multiple hose sections; fuels compatibility (testing or analysis) ; elongation and twist characteristics at working pressure; an analysis of surface smoothness on the inside of the hose (a smooth surface is critical to reduce friction losses); expected durability of hoseline when used in rough environments; and the overall layflat capability of hoseline.

PHASE III: There are potential applications for a high pressure layflat hose in military bulk fuel and water systems. There are also potential applications for this technology in the private sector in applications such as fire fighting and disaster relief where bulk quantities of water need to be pumped over long distances.

REFERENCES:
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2. Military Performance Specification MIL-PRF-370J, Hose and Hose Assemblies, Nonmetallic: Elastomeric, Liquid Fuel.

KEYWORDS: Fuel, Hoseline, Lay Flat, High Pressure

A09-186 TITLE: Improved Tele-Control for Manipulator Equipped Unmanned Ground Vehicles

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

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: TARDEC is constantly investigating various unmanned ground vehicle technologies to counter existing and emerging threats. Significant investments are made to develop tools that will ultimately be used to provide a safer operational environment for soldiers. The objective of this effort is to develop effective fine teleoperation control of one or more manipulators on one or more unmanned ground systems. The system must translate hand and arm movements of the operator(s) to the robot end effector. The control must go beyond inverse kinematics and fly the end effector algorithms. The goal is to enable fine control with actuators that may not be designed for fine control on platforms that may move when the manipulator moves. Solutions must take the momentum and masses of the various bodies into account when moving the manipulator.

DESCRIPTION: This topic is looking for innovative solutions that provide advanced fine manipulator control. This topic is looking for an innovative way to manipulate some object assuming the manipulator is at some known position and orientation near the object, similar to a robotic or arthroscopic surgical system. Surgical systems are typically small, expensive and designed for extremely controlled environments. On the other hand, manipulators on unmanned ground vehicles must operate in a dynamic environment. The end effector may be subject to the movement of the base robot, as well as unconstrained movements of the object of interest. For this topic, teleoperation control devices should be intuitive and useful in harsh and non-controlled environments, including extreme heat, cold and rain.

This topic seeks systems that provide fine manipulator control and give the operator of a manipulator arm the sensation of actually being at the object being manipulated; using the manipulator as an extension of one's own arm and hand. The main focus of this topic is in providing fine, human level manipulation, to the level of being able to handle tools, for example. The system does not require the precision of a surgeon, but does require the precision of a mechanic. Issues that need to be addressed include determining if existing manipulator arms and Operator Control Units (OCUs) are sufficient to perform accurate, fine manipulation, if manipulator arms with coarse control can be adapted to perform fine operations, and what new end effectors and gripper designs are needed. A number of other issues need to be evaluated as part of this topic. The visual system must be evaluated for its effectiveness at providing a good first person view of sufficient quality to perform fine manipulation. Providing proprioceptive feedback, such as how difficult it is to pull out some item, or how much resistance to cutting something there is, is also of interest in this topic. Questions like what benefit does adding additional proprioceptive or haptic feedback (i.e. force feedback, "feeling" the texture of an object) provide and in what situations is it necessary versus only using visual feedback should be addressed.

While the fine manipulator control system should be adaptable to manipulator arms and vehicles of any size, manipulator control of interest for the Phase II demonstration is for manipulator arms on vehicles between 30-200 Kg. For the Phase II demonstration, the manipulator end effector should be capable of holding and using common hand tools, removing batteries and cutting wires. Demonstration should also include a pair of manipulator equipped robots working together as left and right hand effectors.

PHASE I: Develop overall system design to perform fine teleoperation control of manipulator arm end effectors, using as few sensors as possible to efficiently accomplish the task.

PHASE II: Phase II shall produce and deliver a prototype system for performing fine teleoperation manipulator control and a final report documenting all activities in the effort. The prototype system shall include an OCU for viewing the objects for manually controlling the manipulator end effector and for fine control of arm and joints as needed. The Phase II system shall be demonstrated using a manipulator arm with multiple degrees of freedom on an unmanned ground vehicle. For the Phase II demonstration, the manipulator end effector should be capable of holding and using common hand tools, removing batteries and cutting wires. Demonstration should also include a pair of manipulator equipped robots working together as left and right hand effectors. The final prototype system should include all additional sensors needed to perform or augment the fine teleoperation manipulator control, including any sensors providing haptic/proprioceptive feedback and any new end effectors/grippers required.

PHASE III: Potential Phase III military applications include incorporation of the developed control and OCU software for fine teleop manipulator control into existing and future fielded unmanned systems. This includes adding this capability to reduce the time required to perform EOD tasks on currently field EOD robots as well as to gain additional forensic evidence. Potential commercial applications of this technology include using a remote manipulator arm to safely operate tools in dangerous environment, without requiring a structured environment that is the basis for many current industrial robotic applications.
Additional future application may include home devices for elderly or disabled persons.

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3. Learning Inverse Dynamics: a Comparison.Duy Nguyen-Tuong, Jan Peters, Matthias Seeger, Bernhard Scholkopf, Max Planck Institute for Biological Cybernetics.
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http://www.site.uottawa.ca/~petriu/ISJC_2007_27June07.pdf

KEYWORDS: fine manipulator control, dexterous manipulator, control, robot, EOD, UGV, unmanned manipulation, inverse dynamics

A09-187 TITLE: Semi-Autonomous Manipulator Control

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

OBJECTIVE: The objective of this effort is to develop a vision-based system that would allow a mobile robot with a manipulator to autonomously grasp and manipulate a specified object.

DESCRIPTION: This topic is looking for innovative solutions that provide advanced, semi-autonomous manipulator control beyond capabilities like fly-the-end-effector, which still require a significant amount of operator involvement and repetition, and more advanced techniques like bin picking for industrial manipulators that require a fairly well structured environment. The objective is to allow the operator to task a manipulator arm on an unmanned ground vehicle (UGV) to autonomously perform some tedious, time-intensive, or repetitive action, like picking up a debris sample from the ground and placing it into a sample collection bin. The Army currently uses unmanned ground vehicles with manipulator arms, especially in the Explosive Ordinance Disposal area. Currently, most platforms either require full manual control of these manipulator arms, or offer a limited set of presets. This makes the task of positioning and using a manipulator arm to inspect or manipulate some object very tedious and time consuming, especially when the arm has many joints to control. Current state of the art implementations on UGVs with manipulators tend to focus on, at most, the fly the end effector technique, where the user guides the end effector from the end effectors point of view. While this does significantly reduce the workload of the operator, it still requires the operators focus and can take away from time the operator could be spending on other tasks.

There has been a significant amount of research done in semi-autonomous positioning of manipulator arms (i.e. [2]), but this research is focused on getting the end effector to a certain position and then letting the human operator take over. Research in this field has also been done with industrial bin picking using manipulators to pick objects out of a bin (for example [3], applications in [4]). Both these research areas often involve utilizing some model of the environment, using something like stereo vision or other sensors, to drive the end of a manipulator arm to a specific point based on that model. This topic is looking for innovative solutions to semi-autonomously, based on user input, not only guide a manipulator arm end effector to be near an object selected out of a scene, but to also allow the user to autonomously grab or perform some simple or complex operation on or using that object. For example, the user may select a piece of debris and put it in a sampling bin at the back side of the UGV, on the opposite side of the platform, at which point the manipulator arm will autonomously position itself near the object in the proper orientation and state, and then autonomously grab the debris and place it in the sample bin, without requiring any user intervention. This topic is also looking for target tracking, rather than just estimating the location of an object and blindly going to that point. The developed system and algorithms should be able to adjust to effectively grab an object whose position is not known exactly, handle cases where the vehicle shifts when the arm moves, and possibly even grab an object that is in motion relative to the vehicle. Of interest is also being able to specify the orientation of the arm or end effector at the final location near the object, or restrict the path it takes. There should be an intuitive and innovative user interface for efficiently tasking the manipulator arm. This interface may use mission specific profiles to reduce the number of commands. Of interest are interface designs that innovate beyond using menus or buttons to select commands, such as voice commands. The goal of this topic is to perform the semi-autonomous control of the manipulator arm using a single (non-stereo) camera, although other vision systems and sensors may be considered. This is to allow the technique to be used on existing robotic platforms and not require potentially expensive or custom equipment to be added. While the control system should be adaptable to manipulator arms and vehicles of any size, vehicles of interest for the Phase II demonstration are between 30-200 Kg.

PHASE I: The objective of Phase I is to investigate and present techniques that can be used to perform semi-autonomous control of a manipulator arm and semi-autonomous manipulation of an object, using a single camera. Phase I shall document in the final report the algorithms and hardware needed to perform the semi-autonomous control of a manipulator arm and semi-autonomous manipulation of an object, as well as requirements on the Operator Control Unit (OCU). A simulation or simple demonstration is also an objective of Phase I.

PHASE II: Phase II shall produce and deliver a prototype system for performing semi-autonomous manipulator control and semi-autonomous object manipulation and a final report documenting all activities in the effort. The prototype system shall include an OCU for selecting the object to manipulate and selecting how to manipulate the object. Manual override of manipulator control must also be provided. The Phase II system shall be demonstrated using a manipulator arm with multiple degrees of freedom on an unmanned ground vehicle. The final prototype OCU shall demonstrate multiple (as many as possible) autonomous manipulator behaviors, such as turning a door knob, picking up a piece of debris and placing it in a sample bin, emptying a container, etc.

PHASE III: Potential Phase III military applications include incorporation of the developed control and OCU software for semi-autonomous manipulator control into existing and future fielded unmanned systems. This includes adding this capability to reduce the time required to perform tasks on currently fielded EOD and other unmanned systems with manipulator arms. Potential commercial applications of this technology include automating the process using a manipulator arm to safely pick up products or materials that are potentially hazardous, without requiring a structured environment that is the basis for many current industrial robotic applications (i.e. that require some human decision making).

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KEYWORDS: semi-autonomous, manipulator control, robot, EOD, UGV, unmanned, manipulation

A09-188 TITLE: Teleoperation with High Latency

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this research is to develop a system to mitigate control and display issues related to high latency while driving an unmanned ground vehicle through teleoperation.

DESCRIPTION: Even as the Army continues to deploy robots in the field to assist Soldiers, the issue of remote driving with communications and video latency between the robot and its operator remains an important concern. Latency can be caused by a number of factors, including distance, limited bandwidth, compression algorithms, electromagnetic interference and poor line of sight. This latency can cause serious problems for the operator. Latency as low as 170 ms has been shown to significantly degrade a driver's performance in simulated driving environments. Furthermore, mitigating high latency by simply degrading the video quality or lowering the frame rate increases the potential for operator error.

The purpose of this topic is to investigate methods of reducing latency in video and to develop technology to mitigate the effects of unavoidable latency encountered while driving via teleoperation. For latency reduction, the desired outcome is to improve the quality of a teleoperators video feed. This can be done by improving the data transmission rates, reducing packet loss or some other novel method. Another current research path that is being taken regarding the issues of high latency in teleoperation involves the use of three-dimensional representations of the environment and employs physics models of the vehicle and user input to control the vehicle. An advantage to this approach is the ability to simulate different camera angles. A disadvantage is missing subtle cues in the real video. In contrast, this topic is focused on using real video from on-board cameras, with a possible approach being to predict and show the position of the vehicle within the video display. Alternatively, studies have shown that the use of automation in teleoperation of robotic assets mitigates the decrease in performance related to latency. Therefore, another possible approach is to allow the vehicle to steer autonomously, while the operator indicates on the screen where the vehicle should go. The vehicle would then use technology such as visual servoing to steer along the desired path.

The developed latency mitigation system should be applicable to a small unmanned ground vehicle, but should easily scale up to larger vehicles. There is interest in using such a system on larger vehicles traveling at highway speeds. The system shall have a form of reactive obstacle avoidance in order to avoid objects unseen due to the latency in the video stream. The system will be expected to work in the presence of variable frame rate, variable image quality, and latency of up to two seconds. Part of the research for this topic will be to devise an efficient and intuitive design for the driver control interface.

PHASE I: Develop a design for the latency mitigation system. Report out on the planned implementation of the system, the user interface for the operator control unit and design tradeoffs. Conduct proof of principle experiments to support the concept and provide evidence of the viability of the approach.

PHASE II: Fully implement the latency mitigation system. A prototype of the system will be integrated with a small robotic vehicle, and successful operation of the system will be demonstrated in an outdoor environment. In addition to the prototype system, a report will be delivered that documents all activities relating to the project, technical specifications of the system and a users guide.

PHASE III: Commercial applications for this system are possible for all companies that use teleoperated robots. Many industries (emergency rescue, waste disposal, security, etc) utilize teleoperated robots and would benefit greatly from a system that can mitigate control and video issues that are due to latency. Additionally, a wide array of military applications are possible, given the increasing number of unmanned ground vehicles that are being deployed in the field.

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6. http://axiom.anu.edu.au/~luke/doc/acra2000.pdf (Reinforcement Learning for Visual Servoing of a Mobile Robot)

7. http://elvis.rowan.edu/~kay/papers/ices95.pdf (Operator Interface Design Issues in a Low-Bandwidth and High-Latency Vehicle Teleoperation System)

KEYWORDS: latency, teleoperation, operator performance, video quality, lag, frame rate

A09-189 TITLE: Transducer Technologies for Track Health Monitoring

TECHNOLOGY AREAS: Materials/Processes, 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 effort is to design, build, and demonstrate a prototype transducer with the ability to operate and survive in the harsh vehicle track operating environment. The system will provide key parameter data that can be used to develop diagnostic and/or prognostic algorithms that will diagnose track health and predict future track failures. This requirement maps directly to the Maneuver Sustainment FOC; Warfighter Outcome for Reliability.

DESCRIPTION: The vehicle track operates in a harsh environment with many challenges such as heat, dust, and vibration. The track has components made of different materials such as steel, rubber, and other elastomers that hinder the ability to embed a transducer The track also consists of many moving parts, making transducer placement and integration a difficult task.

This effort will result in the design, build, and demonstration of an innovative solution to provide either direct or indirect sensing technologies in rugged environments for current and future track systems. The transducer shall broadcast parameter data mapping directly to the track failure modes and be used to develop diagnostic and prognostic algorithms that will provide a diagnosis of track health and predict future track failures at either a component or system level.

The transducer must have the ability to be integrated into and survive in this harsh operating environment. Available vehicle data parameters broadcasted on the vehicle data bus should also be used in the diagnostic and prognostic algorithms to increase the accuracy of the predictions. The transducer shall interface with the vehicle data bus either directly or through a hardware addon.

PHASE I: Phase I shall result in a detailed report providing the scientific, technical, and commercial merit and feasibility of using transducers for track health monitoring. Different transducer technologies should be evaluated to determine their effectiveness in this specific operating environment. Possible mounting locations for the transducer should be investigated to determine the best fit for integration, taking into account any adverse effects on the reliability and survivability of the track. The data types and data parameters that will be available from the working transducers will be defined. A data analysis plan will be developed to create a path to developing diagnostic and prognostic algorithms for the track system.

PHASE II: Phase II shall result in the design, build, integration, and demonstration of a prototype track health monitoring system. The system shall be rugged and able to survive in the harsh operating environment. The system shall be able to collect the sensor data, analyze the data, run the diagnostic and prognostic algorithms, and display useful engineering data concerning the health of the track system or track components. The system shall be demonstrated on a representative HBCT or FCS tracked vehicle, or an approved commercial vehicle. The demonstration shall show all defined capabilities working in a rugged, moving environment.

PHASE III: Phase III shall result in the integration of the Phase II developed prototype system into either a military platform or a commercial vehicle. Potential applications include any commercial or military tracked vehicles that need the ability to operate and survive in harsh operating environments. The military application will help diagnose and predict failure on combat tracked vehicles, such as tanks. The commercial application will help diagnose and predict failure on bulldozers and other construction equipment. In Phase III, the prototype tested will need to pass MIL-STD-461E and MIL-STD-810F.

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KEYWORDS: CBM, Condition Based Maintenance, Sensors, Transducers, Harsh Operating Environment, Diagnostic, Prognostic, Algorithm, Data Analysis.

A09-190 TITLE: Advanced Condition Based Maintenance (CBM) Characterization Using Data Fusion Techniques

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this effort is to capture and fuse real time data from existing vehicle Engine Control Units (ECUs) and additional sensors such as, but not limited to, Micro-Electro-Mechanical Systems (MEMS) based accelerometers, strain gauges and motion based sensors. Included in this effort is the development and application of a set of robust algorithms to develop an in depth characterization of the vehicle operational picture. This will provide additional data over and above what the Army is use to receiving from traditional Engine Control Units (ECUs) alone.

DESCRIPTION: The US Army is interested in innovative solutions utilizing state of the art techniques in data fusion and sensing technologies. Adding diagnostics sensors to military vehicles often comes with a high price tag. Enabling Condition Based Maintenance (CBM) requires information over and above the traditional subsystem parameters. Current CBM data sets lack the characterization data to push vehicle maintenance from an interval based practice to a condition based paradigm. Data fusion of additional sensors and the traditional vehicle data will help to develop this critical characterization data.

Data mining and data fusion are techniques used for the extraction of hidden information from databases. These processes are ways to analyze data and transform it into useful information. The challenge for the Army is to determine what information from sensors can be fused with the current data bus parameters and what additional information can be gleaned from the result.

The software developed to tie Electronic Control Unit (ECU) data and additional sensors may either be embedded to an ECU level or can be hosted on a computer system (on-board or off-board) used for data mining and rationalization of data. The information gained from this will add important parameters needed to determine the overall health and condition of the system. Advanced algorithms will be developed to fuse conventional parameters with sensor packs to extrapolate detailed characterizations of vehicle conditions based on those parameters.

PHASE I: Phase I will consist of a discovery phase to determine available data bus parameters on selected military platform(s). The military platform(s) will be a representative from the Tactical Wheeled Vehicle (TWV) fleet (i.e. FMTV/LMTV). Phase I will also consist of a top 5 critical data elements list per platform. The top 5 critical data element list shall consist of derived parameters from the data fusion of data bus parameters and add-on sensor(s).

The critical data element list shall take into consideration component cost, add-on sensor cost, and the effect on determining the overall vehicle health status. The Phase I deliverable will result in a detailed report on the proposed top 5 critical data elements per platform. The report shall also include the requisite data bus parameters and add-on sensors for the selected platform(s). This report shall outline which parameters are crucial to enable an inferred sensing capability.

PHASE II: Phase II will use the results from Phase I to develop data fusion algorithms. The algorithms developed shall ensure portability and open interfaces (APIs, code library, source code, etc.). Required Phase II deliverables will include a prototype bench top demonstration that shall use existing data parameters communicated via a data bus simulator along with additional sensor parameters into a "black box" (e.g. desktop or laptop). The demonstration shall prove that the algorithms hosted can fuse ECU data and additional sensor data to provide critical information to determine the overall health of the system.

PHASE III: For the military, this data fusion capability can be applied to all vehicles that have ECUs and/or a data bus. This technology also offers a potential mechanism to generate return on investment from the existing diagnostic architectures on Army legacy ground vehicles. Target fleets could range from tactical wheeled vehicles to combat vehicles. For the commercial sector, applications would be similar to that of the military.

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KEYWORDS: Data fusion, data bus parameters, algorithms, sensors, Condition Based Maintenance (CBM), health status

A09-191 TITLE: Vehicle Blast Data Recorder

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Desired end product of this SBIR project is a blast event and vehicle accident event recorder which can be integrated into any military ground vehicle system in the field or in testing. Project will require definition of sensors required, development of the data recording system, demonstration on a representative ground vehicle system, and validation against current survivability testing methods.

DESCRIPTION: Data recording devices for civilian applications have been used extensively in aircraft and automobile crash event analysis. Similar to vehicle accident recorders in motor vehicles, or the "black box" in an aircraft, a blast event data recorder would help solve the problem of assessing crew injury effects against in-theater threats in order to better propose protection methods. This standalone system could be added to any ground vehicle to record impacts to the vehicle and crew. The final use would be similar to that of the "black box" in aircraft which records the moments up to and including an impact. Data items such as vehicle speed, engine speed, braking information, accelerations, steering position, internal and external pressures, temperatures and audio, etc. could be recorded and stored for analysis of crash data, accident reconstruction efforts, or blast event impulses. Data recording devices integrated in to military vehicles will allow engineers to reconstruct vehicle crash events and blast/IED events in order to better understand the causes of crew injury, and allow better design for troop safety.

In a search of COTS devices, the current state of the art of data recording devices does not allow for the real-time analysis of acceleration data in order to allow for quick assessment of damage due to an event. Current black box devices are simply a means to record the data, which can be recovered later on. In order to improve upon the current state of the art, this project will attempt to proactively determine event severity and communicate that severity through the vehicle communications system.

PHASE I: The Phase I effort will define the data recorder signals required for blast event and crash event analysis, will identify if any commercial-off-the-shelf components are currently available which may provide some of the information required, will determine possible vehicle locations for data recorder installation, identify packaging and power requirements, and sensor frequency response, range, and linearity. The Phase I effort should also identify components which meet the requirements for data collection and recording.

PHASE II: The Phase II effort will require development and manufacture of an event recording device. The device should be installed and tested on a military ground vehicle system, and validated against applicable survivability test data. The event recorder device should be adaptable to fit any ground vehicle with zero or minimal modification to the mounting system.

PHASE III: A Phase III military application would be an add-on, standalone event recorder system which could be integrated into any military ground vehicle system with zero vehicle modification and little, if any, impact on vehicle electrical loads. Potential Phase III commercial applications could be improved automobile, heavy equipment, or aircraft data recording devices. Improved data recording capabilities, with low cost and low power requirements could have many different commercial applications. Another potential Phase III application would be replacement or reduction of sensors used during developmental or operational blast testing of vehicles.

DUAL USE/COMMERCIAL APPLICATIONS: A device with these capabilities could be used in commercial or military applications for condition-based maintenance by recording vehicle usage conditions and statistics in addition to traditional "black box" event recording capabilities.

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2. http://www.bordeninstitute.army.mil/published_volumes/conventional_warfare/ch07.pdf

3. http://www.fmcsa.dot.gov/facts-research/research-technology/tech/vehicle-data-recorders.htm

KEYWORDS: data, recorder, survivability, accident, blast, crash, black box, accelerations, safety

A09-192 TITLE: System Design Optimization Model

TECHNOLOGY AREAS: Information Systems

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 a methodology to rapidly mathematically assess the impact on vehicle survivability through improvements in lethality, mobility, and non armor survivability technologies. This would be used to perform trade-offs between these technologies and other traditional survivability technologies.

DESCRIPTION: The Threat Oriented Survivability Optimization Model (TOSOM) allows the quantification of trades between survivability technology areas (Hit Avoidance, Detection Avoidance, Armor, etc.). The model uses a validated method to assess the probability of survival through the identified kill chain using mathematical methods. Additionally, the incorporation of the Analytical Hierarchy Process (AHP) optimizes the technology selection based on the ratio of benefits to burdens. TOSOM only considers technologies that directly impact the kill chain. This kill chain is the conditional probability of being encountered, detected, acquired, hit, penetrated and killed.

While highly useful, TOSOM does not address the effects of lethality, mobility and other non-traditional survivability technologies such as Situational Awareness (SA) and fire suppression. As an example, the mobility attribute of the system impacts the probability of encounter and the probability of hit portions of the kill chain. This can be quantified using the speed profile of the systems based on the engineering analysis models used to define the performance capability. This effort will provide for the development of a methodology and the requisite software to modify TOSOM to provide the ability to assess and identify trades between mobility, lethality, survivability and other technologies.

PHASE I: Conduct market research to determine the critical metrics for mathematically quantifying the impact to the survivability kill chain from technologies such as lethality (e.g. stability control, bias and dispersion of the proposed system, etc.), mobility (e.g. top speed, acceleration, NATO Reference Mobility Model (NRMM) profile, etc), situational awareness, blast mitigation and fire suppression.

PHASE II: Working within the Government Purpose Rights for TOSOM, develop, demonstrate and refine the software incorporating the mathematical representation of the critical metrics' impact to the survivability kill chain for insertion into TOSOM. Work with Research, Development and Engineering Command (RDECOM) partners to validate and verify the models, methods, and processes in conjunction with Army Materiel Systems Analysis Activity (AMSAA).

PHASE III: Dual Use Applications: Upon completion the TOSOM model will be available to both Government and industry. The model can be used by the defense industry to perform trade-off analyses on Government contracts as well as for in-house efforts.

REFERENCES:

1. Sensitivity of TOSOM Outputs to Threat Tree Variability, Daniel Hicks, Jack Reed, William Jackson, Army Tank-Automotive Command, Warren, MI, Survivability Research Division. http://www.stormingmedia.us/66/6600/A660064.html.

2. Data Requirements for TOSOM; Army Tank-Automotive Research, Development, and Engineering Center, Warren, MI. http://www.stormingmedia.us/23/2383/A238344.html.

3. Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World, New Edition 2001 (Analytic Hierarchy Process Series, Vol. 2) by Thomas L. Saaty

4. Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process (Analytic Hierarchy Process Series, Vol. 6) by Thomas L. Saaty

KEYWORDS: Modeling, Simulation, Survivability, Lethality, Mobility, Situational Awareness, Threat Oriented Survivability Optimization Model (TOSOM), Hit Avoidance, Detection Avoidance, Analytical Hierarchy Process (AHP)

A09-193 TITLE: Variable Speed Alternator Drive

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Present military ground vehicle alternators are over-sized to produce adequate power at engine idle. A variable or multi-speed drive would allow an alternator to develop full power at engine idle.

DESCRIPTION: Military ground vehicle electrical loads have increased significantly in recent years as additional communications, sensing, electronic warfare, and computing equipment has been added. Requirements developers forecast continued growth in onboard electrical demand. For many mission profiles, this equipment is operated when the vehicle in stationary. Batteries have proven inadequate to the task of providing the power required, and most ground vehicle systems lack auxiliary power units. The electrical power requirement is met then by idling the main propulsion engine and drawing the required power from the attached alternator. As variable speed electrical machines, alternators do not develop their rated power at engine idle speeds. Two solutions are currently deployed. One is a "high-idle" setting on the engine, operating the main engine at a higher than normal idle speed just to boost alternator output. This is both fuel inefficient, and also increases the acoustic signature of the vehicle and so its detectability. The second solution is to install an oversize alternator, which will develop adequate power at idle speed. This approach faces space constraint limits and the lack of availability of very large commercial alternators that can be militarized. An innovative solution is required to decouple alternator speed from engine speed. The alternator speed must be greater than engine speed at engine idle, sufficient to develop full power, yet the alternator speed must not exceed design speed at high engine RPM, which is why a simple gearing is inadequate. The drive / alternator assembly must fit into the same space constraints as the current alternator, develop full power at low-idle, and not exceed main engine stall torque at low-idle. The variable or multi-speed drive must be compatible with existing engine / alternator combinations, able to be installed as a simple maintenance action, and require no operator control.

PHASE I: Design a variable or multiple speed drive that meets the objectives of the above description. Using modeling and simulation, validate the design.

PHASE II: Develop the drive designed in Phase I. Validate the design and the modeling and simulation through testing. Measure electrical power quality throughout the operating range to ensure the drive is not inducing electrical variations or electromagnetic interference outside the limits of MIL SPEC requirements, including MIL SPEC 461 and 1275. Demonstrate the drive on a military ground vehicle.

PHASE III: Commerical long-haul trucks routine operate all their hotel loads at engine idle during required driver rest periods. As such, they also install oversize alternators, and so would benefit from the same innovative solution.

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1. http://assist.daps.dla.mil/quicksearch/basic_profile.cfm?ident_number=35789

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3. http://www.pm-mep.army.mil/pdffiles/ORNLReport2.pdf

KEYWORDS: engine, alternator, electrical, power, idle, drive

A09-194 TITLE: Army Ground Vehicle Thermodynamic Waste Heat Recovery System

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Develop and demonstrate a compact, lightweight, efficient, adaptable, and low cost waste heat recovery system for Army ground vehicle applications that focuses on using waste heat effectively to maximize fuel efficiency.

DESCRIPTION: Army "Energy Productivity" policy mandates that all future weapon systems "improve their energy conservation efficiencies ". Efficient energy use in military vehicles can maximize fuel efficiency. One of the main reasons for low fuel efficiency is the waste of heat energy available from diesel engine combustion. There are many pathways to recapture energy that is usually lost as heat, however; many of these have stumbling blocks that prevent their use in military vehicles. This topic is directed toward waste heat recovery systems that use a mechanical system to convert thermal energy to power and focus on the above mentioned characteristics. In a Heavy Equipment Transporter Vehicle System (HETS) the percent of fuel energy lost to coolant and exhaust can be up to 68%. Reusing this energy can provide additional power output and drastically improve fuel efficiency. It is envisioned that a waste heat recovery system would use the waste heat present in the exhaust gases from a HETS 500 hp diesel engine to provide additional power benefits. The challenge is to develop a system that recovers and reuses waste heat in an efficient manner that supports useful power to the vehicle as well as reduces the cost of ownership.

PHASE I: Identify and determine a potential concept design of a waste heat recovery system for the Heavy Equipment Transporter Vehicle System (HETS) that is compact, lightweight, efficient, cost effective, adaptable, and operates within the temperature of exhaust gasses. Perform modeling and simulation of the proposed concept. As a minimum, Phase I deliverables will include an initial concept design, estimate of increase in fuel efficiency and a Phase II development plan. A subscale, prototype may be constructed to demonstrate the feasibility of the concept design.

PHASE II: Fabricate a full scale prototype based on the design developed in Phase I and demonstrate the prototype in the laboratory by integrating it with realistic supporting components and testing in a simulated operational environment. As a minimum, the prototype system will be evaluated on the basis of cost, size, weight, adaptability, performance and the improvement it makes in fuel efficiency at all working points. Provide a detailed plan of Phase III commercialization including descriptions of specific tests, evaluations and integration to be performed.

TRL: (Technology Readiness Level) TRL Explanation Biomedical TRL Explanation TRL 5 - Component and/or breadboard validation in relevant environment

PHASE III: Phase III will address test, evaluation, and integration of the waste heat recovery system in a vehicle for military and commercial applications. The Phase III commercialization plan developed in Phase II will be implemented. Waste heat recovery systems will be applicable to military and commercial off-road equipment. The waste heat recovery system can be applied to stationary commercial diesel generator sets. The waste heat recovery system can be customized to work with Product Improved HEMTTS and FMTV tactical trucks.

REFERENCES:
1. Sandra Hounsham, Richard Stobart, Adam Cooke and Peter Childs, Energy Recovery Systems for Engines, SAE 2008-01-0309

2. Diego Arias, Timothy Shedd, Theoretical Analysis of Waste Heat Recovery from an Internal Combustion Engine in a Hybrid Vehicle SAE 2006-01-1605

KEYWORDS: Waste Heat Recovery System, Energy Conversion, Diesel Engine, Exhaust, Cooling System, Thermodynamic

A09-195 TITLE: Highly Accurate Active Optical Sensor - Proximity Fuze

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Demo of a highly accurate active optical sensor proximity fuze that can detect passing threats and trigger countermeasure. Sensor/fuze must detect all classes of threat projectiles dangerous to ground combat vehicles.

DESCRIPTION: Some current Army active protection system concepts use a countermeasure delivery munition with an on-board infra-red (IR) sensor to sense an incoming threat and tell the countermeasure when to fuse the warhead. Current designs are optimized for specific threats and have varying levels of performance across different threat classes. There is a need to have a fusing mechanism that can function to a high degree of reliability and performance against the full spectrum of threats. The results of this SBIR effort may provide useful new approaches and designs to increase the performance of current Army designs against the full spectrum of threats.

PHASE I: Highly Accurate Active Optical Sensor - concept design options development, evaluation and selection. The contractor shall devise concept options. The contractor shall evaluate the concept options, given the potential application and operating limits. The contractor shall select the most acceptable and most cost effective design. The contractor may conduct limited proof-of-principle component level experiments to verify the selected design.

PHASE II: Highly Accurate of Active Optical Sensor system design proof-of-principal experiments, sensor/fuze capability evaluations, prototype development and static field experiments/demonstrations against a range of RPG, ATGM, Tank Fired HEAT and KE threat munitions, at Government controlled test sites. The contractor shall develop, assemble, tests and deliver to the Government prototype systems capable of detecting the fly-by of selected threat munitions and providing a "trigger signal" to activate a simulated countermeasure.

PHASE III: The results of this SBIR may become useful for the Army Active Protection System designs. Some key functional components still being developed in current Army APS concepts may need support in providing a more accurate indication of the passing threat. Technology from this SBIR could be useful to the Army's APS efforts

The results of this SBIR could be useful for automotive collision avoidance, lane changing and/or parking assistant subsystems. The NAC and/or TARDEC GSS may be interested in applying some elements from this SBIR on robotic vehicle systems.

REFERENCES:
1. ADA469061, FCS Technology Insertion and Transition, Author: Paul Rogers, 18 Apr 2007, Report # TARDEC-17067

2. ADA468965, Defense Acquisitions: Analysis of Processes Used to Evaluate Active Protection Systems, Report # GAO-07-759

KEYWORDS: Sensor, Detection, Prox-Fuze, Countermeasure (CM), munition, APS (Active Protection System)

A09-196 TITLE: Autonomous Indoor Mapping and Modeling

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

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: A system for generating a three-dimensional computer graphics database of the interior of a building, suitable for a small robot.

DESCRIPTION: Obtaining a realistic high-resolution three-dimensional graphics database for the interior of building, prior to soldiers entering the building, is of significant interest to the Army. With advances in computing power, miniaturization of sensors, and autonomous behaviors, this capability is becoming feasible for a commercial product. There has been, and continues to be, large efforts into solving the simultaneous localization and mapping (SLAM) problem, using both laser and camera systems, with commercial devices on the horizon. This topic seeks to build on that work and produce not only two-dimensional maps of the building interior, but also generate texture-mapped three-dimensional representations, which the soldiers could fly through in mission rehearsal. The data necessary for building the model would need to be gathered at the same pace as the map building and exploration. The intent is for the robot to autonomously explore a building, while generating the three-dimensional graphics database. The system's weight, size, and power requirements should be suitable for vehicles that are capable of indoor navigation. Many of the existing research efforts use manned or teleoperated passenger vehicles, which have relatively smooth rides and sensors mounted far from the ground, as opposed to autonomous small unmanned ground vehicles that can have substantial pitching and rolling and have sensors mounted relatively close to the driving surface. While this topic is focused on indoor mapping and modeling, there is also interest in performing the same operation outdoors. While the preference is to use only on-board cameras, other sensors would be acceptable to increase performance.

PHASE I: The first phase consists of developing the system design, investigating signal/image/video processing techniques, and showing feasibility on sample data. Documentation of design tradeoffs and feasibility analysis shall be required in the final report.

PHASE II: The second phase consists of a full implementation of the system, including sensors. At the end of the contract, the mapping and modeling capabilities of the prototype system shall be demonstrated in a suitable indoor environment. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in this project and a user's guide and technical specifications for the prototype system.

PHASE III: Commercial applications include many UGV applications, such as security and inspection, hazardous waste monitoring, and planetary exploration. Military applications include robotic mule, scout vehicles, security and inspection.

REFERENCES:
1. http://robotics.stanford.edu/~koller/Papers/Montemerlo+al:IJCAI03.pdf (FastSLAM 2.0: An Improved Particle Filtering Algorithm for Simultaneous Localization and Mapping that Provably Converges)
http://www.vision.caltech.edu/mariomu/research/papers/vSLAM-ICRA2005.pdf (The vSLAM Algorithm for Robust Localization and Mapping)

2. http://asl.epfl.ch/aslInternalWeb/ASL/publications/uploadedFiles/nguyen_2006_orthogonal_slam.pdf (Orthogonal SLAM: a Step toward Lightweight Indoor Autonomous Navigation)

3. http://www.compsci.hunter.cuny.edu/~ioannis/cvpr06.pdf (Multiview Geometry for Texture Mapping 2D Images Onto 3D Range Data)

4. http://www.cs.unc.edu/Research/urbanscape/

5. http://www.aass.oru.se/~han/papers/iros2004biber.pdf (3D Modeling of Indoor Environments by a Mobile Robot with a Laser Scanner and Panoramic Camera)

6. http://www.rec.ri.cmu.edu/projects/sacr/index.htm (Soldier Awareness through Colorized Ranging)

KEYWORDS: robotics, navigation, unmanned, mapping, localization

A09-197 TITLE: <u>Durability Modeling and Simulation of Composite Materials</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The ability to model and simulate composite materials for durability is important to understanding their long term use on Army ground vehicles. Composites are inherently more complex than traditional metal materials and suffer from failures due to classical fatigue, delaminating, and even water retention. Furthermore, their long-term use on Army vehicles isn't well understood from this durability perspective. The objective of this topic is to develop a composite material model and post processing tool that can be used with existing Finite Element Analysis (FEA) software that accounts for these types of durability failures and accurately represents the mechanical properties of the composite.

DESCRIPTION: Currently, composite materials are modeled using generic elements found in FEA tools such as Abaqus or LS-Dyna. These generic elements often provide configurations to account for layers and weave patterns, but often lack good models for more complex 3D weave structures or adhesive layers. Without these details, cyclically loading a meshed composite element may not yield all of the likely failure modes. A more complex composite element is required for use in commercial FEA tools that can account for failures internal to the composite material, so that a simulation can over time show where bulk failures will likely occur. Furthermore, new post processing tools shall be required to perform the equivalent of rainflow fatigue counting for composite materials.

Advanced composite material models and post processing tools should also account for extreme variations in mechanical properties at various temperatures. This includes extreme cold where polymer layers may become brittle or de-adhere or extreme heat where they may behave semi-fluid. A sophisticated post processing tool may require stochastic information to be used as environmental inputs, such as percent of time under certain conditions, and similarly produce stochastic outputs to feed other long-term predictive models. It isn't unreasonable to expect that a material model may require going beyond the traditional FEA-material level interfaces in the software to yield more relevant results for post processing.

A contractor working on this project should have a very strong background in composite material testing in particular under cyclic loading and have a good understanding of common degradation modes in composites. It is desirable that the contractor have access to their own testing facilities, since material testing is also required to validate models when they are complete. This topic is also open to exploring other failure and degradation modes that the author may not have mentioned. No relationship with an existing FEA tool vendor is required as long as proper software interfaces exist, and custom FEA tools are also acceptable for using the material model. A key performance factor in the composite material model will be its speed when running in parallelized simulations on a high performance computer cluster.

PHASE I: The Phase I project will be a feasibility study to test out a material model to FEA tool interface and lay out the theories behind the proposed material model and post processing tool. The test of the FEA interface can be conducted with a simple composite material element that is usable in an available FEA tool. The rest of the feasibility study will lay out the parameters that the new composite material model will handle and the mathematical models that drive the additional post-processed parameters. The material model shall be sensitive to mechanical loads and thermal conditions such as extreme hot or cold temperatures near the breakdown of the composite material. The material element shall simulate degradation or failures at individual layers in the material and respond to those appropriately during simulation and for visualization. A post processing tool shall be developed to compile the simulation results and assess expected degradation over extended periods of time. The final deliverable of the Phase I project will be the simple case composite material model and the proposed parameters and mathematical descriptions of the fully developed material element.

PHASE II: The Phase II effort will develop the mathematical models from the Phase I study into implementation in the new composite material element and corresponding post processing tool. As it is being developed, the new composite material element and corresponding post processing tool shall be tested on a high performance computer environment at TARDEC or at the contractors location. The element testing will ensure the integrity of the element, find and correct errors, and assess the material elements performance in terms of processing speed. When the model is finished, it shall be validated using physical testing with random composite material samples provided by TARDEC or by the contractor. All physical testing shall be done at the contractors facility and the results of the testing along with a comparison to simulated data will be evaluated by TARDEC. The outcome of the Phase II effort shall be a working beta version of the composite material element and post processiing tool for use with commercially available FEA software in a high performance computing environment.

PHASE III: Phase III will apply the new composite material element and post processing tool in various Army ground vehicle engineering studies. Of primary interest is application to composite armor materials and how those materials degrade over time. The composite material element will be applied to the various composite structures on a vehicle FEA and the model will be parameterized for changes in temperature and vehicle driving load conditions. The developed post processing tool shall be used to process the results of the FEA to identify stochastic degradation metrics over several years of repeated exposure to the simulated conditions. A similar process will be done for traditional fatigue life of components using already existing fatigue software. These analyses can also be applied to new composite structures in tactical vehicle frames or hulls in addition to new armor structures.

Potential customers of this technology include engineering oems and support firms developing products using composite materials where durability is a key performance factor. There are many dual use applications of this technology in commercial and military industries, including aerospace, automotive, and construction.

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1. Damage and interfacial delamination modeling in composite materials
http://www.iacm-eccomascongress2008.org/admin/files/fileabstract/a103.pdf

2. Modeling polymer melt flow using the particle finite element method
http://fire.nist.gov/bfrlpubs/fire07/PDF/f07064.pdf

3. A fatigue damage model for composite materials
http://www3.interscience.wiley.com/journal/121381753/abstract

4. Stochastic modeling of fatigue crack damage for information based maintenance
http://www.springerlink.com/content/v5u28439018m0332/

KEYWORDS: Composite, Fatigue, Delamination, Degradation, Model, FEA, Stochastic, Lifecycle

A09-198 TITLE: Fatigue Life Modeling & Simulation of Elastomer-Polymer Materials

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The ability to model and simulate elastomer materials for fatigue life is important to understanding their long term reliability on Army tracked ground vehicles. Elastomers are inherently more complex than traditional metal materials and suffer from failures due to classical fatigue and temperature degradation. Furthermore, their long-term use on Army vehicles isn't well understood from a fatigue life perspective. The objective of this topic is to develop a elastomer material model that can be used with existing Finite Element Analysis (FEA) software that accounts for fatigue life and accurately represents the non-linear properties of the elastomer.

DESCRIPTION: The existing fatigue life predictions of rubber are evaluated from test data; there is no direct way to predict the life cycle of rubber. Two methods are used to determine rubber damage which are; the strain energy density criterion, and the cracking energy criterion. These methods are correlated to test results, so the fatigue life is not calculated directly. It is rather calculated based on the stain and crack sizes obtained from the physical tests.

The cracking energy density criterion method predicts a life cycle off by a factor of 2.
The strain energy density criterion gives a life estimate off by a factor of 70. Certain methods have been developed for elastomer fatigue calculation methods from strain obtained from physical tests and then correlated to FEA strain. Nevertheless currently there is no direct method to predict fatigue life of elastomers using modeling and simulation and the next step would be to develop a FEA method or software or interface with current FEA tool that is capable of predicting fatigue life for ealstomers.

Advanced elastomer material models should also account for environmental effects on the elastomer material, such as change in mechanical properties at various temperatures. This includes extreme cold which may lead to elastomer material hardening or extreme heat which may lead to failure.

It is desirable that the contractor have access to their own testing facilities, since elastomer material testing is also required to validate models when they are complete. This topic is also open to exploring other failure and degradation modes that the author may not have mentioned. No relationship with an existing FEA tool vendor is required as long as proper interfaces exist, and custom FEA tools are also acceptable for using the elastomer material model. A key performance factor in the elastomer material model will be its speed when running in parallelized simulations on a high performance computer cluster.

PHASE I: The Phase I project will be a feasibility study to test out a elastomer material model to FEA tool interface and lay out the fatigue life theories behind the proposed material model. The test of the FEA interface can be conducted with a elastomer material element that is usable in an available FEA tool. The elastomer material model shall be sensitive to mechanical loads and thermal conditions such as extreme hot or cold temperatures. A post processing tool may be developed to stochastically compile the simulation results and assess expected degradation over extended periods of time. The final deliverable of the Phase I project will be the elastomer material model and the proposed parameters and mathematical descriptions of the fully developed elastomer material to predict fatigue life.

PHASE II: The Phase II effort will develop the mathematical models from the Phase I study into implementation in the new elastomer material model. As it is being developed, the new elastomer material shall be tested on a high performance computer environment at TARDEC or at the contractors location. The material model testing will ensure the integrity of the model and a method to assess fatigue life for elastomeric materials, find and correct errors, and assess the material models performance in terms of processing speed. When the model is finished, it shall be validated using testing with random elastomer material samples provided by TARDEC or by the contractor. The fatigue life or damage assessed for different samples should not have a big deviation. All testing shall be done at the contractors facility and the results of the testing along with a comparison to simulated data will be evaluated by TARDEC. The final outcome from the Phase II effort shall be a working beta version of the elastomer material model for use in available FEA software in a high performance computing environment.

PHASE III: Phase III will apply the new elastomer material element in various Army ground vehicle engineering studies. Of primary interest is the application to elastomer materials and their non-linaer behavior. The elastomer material will be applied to the various tracked vehicles using FEA and the model will be parameterized for changes in temperature and vehicle driving load conditions. A similar process will be done for traditional fatigue life of components using already existing fatigue software. The developed post processing tool shall be used to process the results of the FEA to identify stochastic degradation metrics over several years of repeated exposure to the simulated conditions. The methodology or software will be delivered to TARDEC for internal use to predict fatigue life of elastomers.

There are potential uses of this methodology in the commercial ground vehicle OEM community as well as tire manufacturers and makers of suspension components. There are strong dual use poosibility to this technology for both military and commercial applications.

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2. Zhao.J., Li.Q., Shen.X., (2008) Finite Element Analysis and Structure Optimization for Improving the Fatigue Life of Rubber Mounts. Journal of Macromolecular Science, PartA, 45, 479-484.

3. Woo. C., Kim. W., Kwon. J., (2008). A study of the material properties and fatigue life prediction of natural rubber component. Material Science and engineering A 483-484, 376-381.

KEYWORDS: Fatigue, Life, rubber, Strain, Crack, Model, FEA, polymer

A09-199 TITLE: <u>Ultra High Pressure Jet Propellant-8 (JP-8) Fuel Injection</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: To examine, develop and demonstrate a hydraulically intensified, ultra high fuel injection system that will be durable, increase power density relative to volume and or weight, increase fuel economy, and reduce specific heat rejection of high output military diesel engines that are required to operate on heavy-hydrocarbon fuels which includes Jet-A1, Jet-A, JP-5, JP-8, and DF-2.

DESCRIPTION: Vehicles are expected to operate in ambient conditions of 125 F down to below -40 F while experiencing significant solar radiation loading and a high concentration of airborne particles. Under these conditions vehicles are expected to perform and fuel systems be durable on a variety of fuels including Jet-A1, Jet-A, JP-5, JP-8, and DF-2. Optimal diesel engine performance targets include minimization of heat rejection, inclusion of significant torque rise for transient operation, peak thermal efficiency (>40%). Ultra high fuel pressures should be utilized (>40,000PSI), roughly 50% greater than current state of the art, to improve the combustion process. Fuel system control hardware shall allow for delivery of small quantities of fuel and fuel rate shaping. The fuel injection system will be evaluated for wear and durability while operating with JP-8 fuel. Hardware shall be demonstrated on an engine relevant to the Army in a size between 6 to 9 liters.

This topic will strictly focus on optimizing a diesel engine fuel injection system that targets the aforementioned performance targets through use of hydraulically-intensified ultra high pressure and multi-pulsed fuel injection events.

Success is dictated based on technological advances made to improve future military diesel engines.

PHASE I: Identify and determine potential hydraulically-intensified fuel system technology that will target military engine requirements shown in the description section. Contractors are expected to develop concept(s) using engineering analysis and also provide a representative bench top demonstration of any proposed concept(s).

PHASE II: Demonstrate, validate, and optimize the fuel injection system toward meeting military engine requirements shown in description section. This hydraulically-intensified fuel system should be demonstrated on a military relevant engine.

PHASE III: Develop a fuel injection system strategy that will both meet military engine requirements given in the description section and also aide commercial engine manufacturers. This technology could be integrated into future military truck engines and also in commercial truck engine applications, with the differential in application based on engine control strategy variants. Additionally, future military light to heavy-duty vehicles could benefit from this fuel injection system development by minimizing multi-fuel power loss and possible fuel economy penalties associated with using JP-8 versus DF-2. It is envisioned that the developed fuel injection system strategy will be transitioned to a military engine supplier for production consideration.

REFERENCES:
1. "Research Needed for More Compact Intermittent Combustion Propulsion Systems for Army Combat Vehicles", Volume 1, Executive Summary and Main Body, Southwest Research Institute, Interim Report TFLRF No. 296, Blue Ribbon Committee Report, 1995.

2. "On the Availability of Commercial Off-the-Shelf(COTS) Heavy-Duty Diesel Engines for Military Ground Vehicle Use", Peter Schihl, SAE Paper No. 2009-01-1099, 2009.

3. P. Schihl, L. Hoogterp, and H. Pangilinan, "Assessment of JP-8 and DF-2 Evaporation Rate and Cetane Number Differences on a Military Diesel Engine", SAE Paper 2006-01-1549, 2006.

KEYWORDS: hydraulically intensified fuel injection, high power density, diesel engine, electronic control

A09-200 TITLE: <u>Advanced Battery Management System Development (including advanced prognostic and diagnostic capability)</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: To develop an active lithium-ion battery management system that ensures adequate, safe, and reliable operation of lithium-ion battery packs by providing a means to determine accurate and precise state of charge, state of health, and state of life information while the battery pack is in use, which will in turn enable real-time production of enhanced battery prognostic & diagnostic information.

DESCRIPTION: Lithium batteries have been used for many years in military and civilian products, including hybrid vehicles, unmanned aerial vehicles (UAVs), and communications equipment. Proper electric and thermal management of a battery pack, consisting of many modules of cells, is imperative. During operation, voltage and temperature differences in the modules/cells can lead to electrical imbalances from module to module and decrease pack performance by as much as 25%. An active battery management system (BMS) is a must to monitor, control, and balance the pack.

PHASE I: Conduct research to investigate and evaluate the lithium-ion battery state of charge (SOC) estimation method, and advanced prognostic and diagnostic methodologies. Phase I will address the methodology development and preliminary verification on cell level. An improvement of battery SOC estimation to 5% accuracy during cycle life and proper state of life (SOL) and state of health (SOH) monitors are anticipated. A research study in the form of a report is also expected from phase I deliverables.

PHASE II: This phase will cover the development and demonstration of BMS hardware and software for lithium-ion battery modules with at least 10kWh (cylindrical or prismatic cells). The BMS should include the function of reporting battery status including battery cell temperature, battery voltage, battery available power (for 2s and 15s), remaining capacity, battery SOC/SOL/SOH. It should also include a safety function to prevent battery overcharge/overdischarge and to assure proper cell/module balancing. Delivery shall include a BMS demonstrator for lab verification and evaluation. The BMS should be able to transmit its SOC/SOH/SOL data to an outside control module (CM) via a serial data bus such as CAN 2.0B.

PHASE III: Technology developed in this topic would be scaled up for the control of large battery packs for hybrid vehicles, electric vehicles, and for other commercial and military applications. The results of the development of the BMS should enable their incorporation into new types of military and commercial vehicles and equipment for lithium-ion battery safe applications, viable battery control, and reduced battery system maintenance cost by providing better predictors of continued battery performance during operation, providing enhanced cell balancing between cells in a pack, and by providing enhanced real-time diagnostic & prognostic data.

REFERENCES:
1. G. L. Plett, Battery Management System Algorithm for HEV Battery State-of-Charge and State-of-health Estimation, Advanced Materials and Methods for Lithium-ion batteries, 2007, ISBN: 978-81-7895-279-6, eds: Sheng Shui Zhang.

2. S. Santhanagopalan, and R. E. White, Online Estimation of the State of Charge of a Lithium Ion Cell , J. Power Sources, 161, 1346 (2006).

3. E. Meissner and G. Richter, Battery Monitoring and Electrical Energy Management Precondition for Future Vehicle Electric Power Systems, J. Power Sources, 116, 79(2003).

KEYWORDS: battery, battery management system, state of charge, state of health, state of life, lithium ion

A09-201 TITLE: <u>Lower Life Cycle Cost, High Strength Heat Resistant Polymers for Track Bushing & Pads</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Reduce life cycle costs of track systems through the development of a new polymer material to enhanced track system durability and performance.

DESCRIPTION: Track systems are the second highest maintenance cost of military track vehicles. Track systems involved a track shoe, road pad, backing pad, rubber bushing, center guide, end connector, and track pin. Any improvement in track life will contribute greatly to reducing life cycle costs of military track systems. Track failure is mainly caused by failure of the rubber components of the track (bushing, road pad, backing pad). Current rubber based components are exposed to extreme conditions involving heat (ambient temperatures of 160F), elements (sand, dirt, mud, rocks) and high loads (5K-10K lbs track tension, up to 70 ton vehicle weight, 45+mph), causing accelerated wear and break down. Previous researched involved bushing design modification (modifying bushing donut design), varying compression ratios of rubber bushing, investigating effects of insertion process on bushing, the use of fillers in rubber production, utilizing rubber substitutions, and bushing lifecycle testing.

PHASE I: Phase I consists of the research and development of polymers applicable to track systems. Multiple tests must show lower hysteries, better management of mechanical energy, lower creep, and better heat transfer than natural rubber by 25%.

PHASE II: Phase II includes delivery of five bushings for in house testing at TARDEC on bushing testing machine. Bushing must show a 25% improvement in Radial and Torsional Stiffness on bushing test machine compare to T-158 production bushing.

After successful completion of lab testing, one track strand must be produced for field testing (A strand signifies one whole track loop on one side of vehicle, ~150 pins with bushing). Field testing will be held at Yuma Proving Grounds, Arizona. Prototypes must fit Abrams track vehicle (T-158 track system). Vehicle will be outfitted with prototype track on one side and production track on other side. Prototypes must demonstrate that the track system cost is $45 per mile or less (Production price of track divided by miles to failure. Price includes entire track system; rubber components/Shoe Body/Pin/End Connectors/ and Centerguide).

PHASE III/ DUAL USE APPLICATIONS: Implement new polymer bushing into Abrams vehicle for operational testing. Military vehicles highly utilize rubber components. A high performance polymer can be implemented as replacements to many parts to lower life cycle cost and increase reliability. Every military and commercial vehicle, ship, and aircraft uses rubber components and will benefit from high performance polymers. Such as in suspension systems, tires, seals, mounts, and track systems.

REFERENCES:
1. MIL-DTL-11891

2. MIL-QPL-11891

3. ASTM D429

4. ASTM D518

5. ASTM D573

6. ASTM D792

7. ASTM D1149

8. ASTM D2084

9. ASTM D2137

10. ASTM D2240

11. ASTM D3182

KEYWORDS: Polymer, rubber, track, Abrams, bushing, Dual use, commercial, production method

A09-202 TITLE: Enable the Main Vehicle Engine to Operate Efficiently in Silent Watch Services at 15 to 20% of its rated power

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: The objective of this R and D work is to enable the main vehicle engine to operate efficiently in vehicle silent watch services at 15 to 20% of its rated power. Another objective of this R and D work is to lower the vehicle engine fuel consumption rate (lb/hp-hr) during silent watch services of at least 10% relative to traditional Auxiliary Power Unit fuel consumption rate (lb/hp-hr).

DESCRIPTION: A latest in technology multi-cylinder truck diesel engine of high brake thermal efficiency and with power range of 240 to 700 BHP ratings, shall be selected and equipped with advanced technology COTS power components. Methods shall be researched and laboratory tested to enable the selected engine to operate efficiently in the Auxiliary power requirement regime of the vehicle silent watch operations, and to lower the brake specific fuel consumption [lb/hp-hr]. These efforts are to reduce fuel burden costs and associated logistical footprint.

PHASE I: Select a latest in advanced technology multi-cylinders truck diesel engine of 40% brake thermal efficiency and of power range of 240 to 700 BHP. Test the selected base engine for performance using DF2 and JP8 fuels for full and part loads of 100%, 80%, 60%, 40%, 20%, and 15%. Generate the fuel map of the engine and analyze the engine performance (Power, torque and BSFC versus RPM) for JP8 and DF2 fuels and for each load settings, full and part loads). Investigate, evaluate and propose the latest in technology COTS power components (Super-Turbocharger with variable geometry nozzle design, common rail fuel injection system, dual nozzle fuel injection system, cooling and lubrication systems, piston ring-liner oil delivery system, and engine and fuel electronic control system). Prepare technical reports addressing the detailed work accomplished.

PHASE II: Incorporate into the engine enabling technology of COTS power components selected in Phase I. Test the new modified engine with COTS power components using fully instrumented engine-dynamometer test rig for performance with DF2 and JP8 fuels at full and part load of 100%, 80%, 60%, 40%, 20%, and 15%. For each run measure, record, document and plot power, torque and fuel consumption diagrams. Repeat the test at 40%, 20%, and 15%. Model, simulate, calculate, and optimize the engine to output the required sustained power and to lower fuel consumption during vehicle mission of silent watch services.

In addition, conduct extensive fuel consumption performance tests (lb/BHP-hr) at 40%, 20%, and 15% of full load at full range of engine speed from near idle to rated engine speed, optimize and measure the air/fuel ratio to be at 23/1 maximum at full and part loads including the 40%, 20% and 15% engine loads. Analyze data obtained from tests for engine power output and for fuel consumption rate during silent watch services simulation.

Optimize the turbocharger air flow to engine, run the engine at various RPM, at each RPM reading, measure air flow volume and pressure to engine, plot the data on the turbocharger map. Analyze the optimum matching of the engine and turbocharger.

In addition, install on the engine a different fuel nozzle with smaller injection holes that to simulate the partial load tests of fuel nozzle with larger injection holes. Test the engine fully on the dynamometer; record, document, and plot power, fuel consumption rate and torque diagrams. Design, calculate, model simulate, and optimize the engine to output the required sustained power and operational capability to satisfy the mission silent watch requirement in power and in reduced fuel consumption rate (lb/hp-hr).

Analyze and compare the delivered power and fuel consumption rate to the tests conducted with standard nozzle with larger fuel injection holes.

Evaluate, analyze and install into the engine system a COTS fuel injector with nozzle having smaller injection holes, and together with COTS turbocharger with variable geometry nozzle designs. Test for full and part loads at various RPM, check outputted data for this combination (COTS turbocharger and fuel nozzle)to validate the required operational capability of the COTS modified engine in meeting the power and fuel consumption requirements during silent watch service operations.

It is expected that for vehicle silent watch service operation, a successful engine system designs and tests should result in meeting the requirements of the subject topic in power output of 20% of rated engine power, and in fuel consumption rate of at least 10% lower than the traditional Auxiliary Power Unit fuel consumption rate [lb/BHP-hr].

PHASE III: Further extensive testing will be conducted on the engine demonstrator in the laboratory to validate the performance of the engine in fuel consumption rate, power, and torque. Test reports will be produced to document the fuel consumption rate improvements in the silent watch regime operations.

Technology developed from these efforts may have the potential to be employed in military tracked, wheeled, and in commercial trucks.

REFERENCES:
The following are SAE Publications on related subject of APU listed as follows and are useful references in designing the subject topic.

1. APU for truck applications

2. SAE Paper no. 2005-01-0653

3. SAE Paper no. 2004-01-1586

4. SAE Paper no. 2003-010266

5. SAE Paper no. 2002-01-3135

6. Technical Abstract- Green Diesel- Technical papers to DOE Fuel system Section and Fuel Injectors. Buck Diesel Power, Inc. May 12, 2009

In addition the following are three research papers on variable orifice nozzle (VON). The objective of the nozzle study is to design a virtual nozzle to reduce CO2, NOx, and Particulate emissions. A fully functional nozzle of VON type and turbocharger-generator concepts are new and have not emerged yet from research laboratories.

7. SAE PAPER 2000-01-0941

8. SAE Paper 2000-01-0943

9. SAE paper 950081

KEYWORDS: Main vehicle engine, silent watch mode of operation, part load, endurance tests, engine rated power, specific fuel consumption rate, performance tests, Super-turbocharger, fuel injection nozzle, engine and turbocharger maps.Power and fuel consumption requirements. rated engine speed, rated power, torque and brake specific fuel consumption.

A09-203 TITLE: Vision-Based Motion Sensing for Small Unmanned Ground Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: The objective is for a low-cost non-contact sensor that can measure a vehicle's motion, independent of GPS, inertial sensors, or wheel encoders.

DESCRIPTION: Obtaining accurate vehicle motion data in many situations can be difficult, especially for small ground vehicles that are driving fast in off-road environments. Odometry does not provide accurate information when the wheels slip, when the vehicle loses contact with the ground, with skid steering, or for pedestrians or future legged robots. Inexpensive inertial sensors have difficulty maintaining accuracy even for short periods of time and GPS information is not always available. This topic seeks a system that directly measures full vehicle motion using a non-contact sensor, such as a camera, which is the preferred choice since most unmanned systems are already equipped with cameras. It makes sense to use inertial sensors as auxiliary devices to improve performance. Although there is a substantial amount of research into visual odometry, most of the existing commercial non-contact motion sensors are for automotive road testing and many only measure longitudinal motion. The sensor desired in this topic must work in dirty environments, with substantial vibration and shock, and with the vehicle pitching and rolling. The sensor is expected to be used on small autonomous vehicles and therefore the system needs to be inexpensive, light-weight (<500 g) and use minimal power (<2 W).

There has been a significant amount of work on structure from motion algorithms, which provide not only the ego-motion of the camera, but also range information. While the ranging portion of those algorithms is not the focus of this project, it could be provided as a by-product. Alternatively, the desired egomotion algorithm could perhaps be made more robust or faster, when the range information is not needed. There has also been related research into augmenting inertial sensors with vision-based motion estimates, which is similar to this research effort. While there are a number of very good research systems in development that perform visual odometry, they are still rather bulky prototype devices. This topic seeks to develop a small inexpensive self-contained hardware system. The hardware system should be modular in that it should be relatively easy to swap in different cameras or inertial units. Also of interest is low-light capability and software for using a vehicle's existing camera and inertial systems. The accuracy of the system should approach 0.1% of distance traveled.

PHASE I: The first phase consists of developing the system design, investigating signal/image/video processing techniques, and showing feasibility on sample data. Documentation of design tradeoffs and feasibility analysis shall be required in the final report.

PHASE II: The second phase consists of a full implementation of the system, including sensors. At the end of the contract, the motion sensing capabilities of the prototype system shall be demonstrated in suitable indoor and outdoor environments. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in this project and a user's guide and technical specifications for the prototype system.

PHASE III: The goal of the topic is a self-contained sensor that can be used on small military unmanned ground vehicles (UGV's). Commercial applications include many UGV applications, such as security and inspection, hazardous waste monitoring, and planetary exploration. Military applications include robotic mule, scout vehicles, security and inspection.

REFERENCES:
1. http://www.gmheng.com/speed_sensor.htm

2. http://www.corrsys-datron.com/optical_sensors.htm

3. http://www.ri.cmu.edu/pub_files/pub2/dellaert_frank_2000_1/dellaert_frank_2000_1.pdf (Structure from Motion without Correspondence)

4. G. Haas and W. Oberle, "Toward fusion of camera-based egomotion and inertial navigation for a UGV (unmanned ground vehicle) traversing natural terrain," Unmanned Ground Vehicle Technology VI, SPIE Proc. 5422, 44 (2004).

5. P. Corke, J. Lobo, and J. Dias, An Introduction to Inertial and Visual Sensing, Int. J. Robotics Research, 26, 519-535 (2007)

6. http://paloma.isr.uc.pt/inervis/inervis2008/

7. http://robotics.usc.edu/~jonathsk/research/publications/2008_Kelly_Fast.pdf (Fast Relative Pose 8. Calibration for Visual and Inertial Sensors)

8. http://www-robotics.jpl.nasa.gov/publications/Mark_Maimone/rob-06-0081.R4.pdf (Two Years of Visual Odometry on the Mars Exploration Rovers)

9. http://www.isd.mel.nist.gov/PerMIS_2006/proceedings/PerMIS_papers/SS1/PerMIS06.Final_SS1-3-Zhu.pdf (An Improved Stereo-based Visual Odometry System)

10.http://www.ai.sri.com/conf/iros2007/3.pdf (Large Scale Visual Odometry for Rough Terrain)

KEYWORDS: robotics, navigation, vision, unmanned, egomotion, structure from motion, inertial sensor, visual odometry

A09-204 TITLE: Standards Based Unmanned Ground Vehicle Mission Language Translator with Graphical Planning Tool.

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

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

OBJECTIVE: Military Commanders express their mission plans in high level terms, aided by graphical icons on maps. Robots, on the other hand, respond to specific primitive commands often modified by sensor input. The intent of the Department of Defense (DoD) is that future robots will comply with a standard set of primitive commands. Tools and techniques are needed to translate between a commander""s intent and the robot""s primitive abilities. The objective is to create an innovative implementation of a grammar that translates between the mission model and the robot capability models generate robots command graphs from mission graphs.

DESCRIPTION: Interface standards, such as the Joint Architecture for Unmanned Systems (JAUS) for unmanned systems are currently focused on relatively low-level control of remotely operated systems. As an example, JAUS provides a complete message set for remotely moving a vehicle, sending imagery and telemetry data back to a operator control station, and even some waypoint following. These interfaces are adequate for direct control of an unmanned platform, but offer little in the way of abstract mission planning. The goal of the Mission Language Translator is to provide users with a graphical-based mission planning tool that focuses on the commanders intent, not the needs of the robot platform. Examples include perimeter patrols, formations, or unexploded ordnance sweeps, all designated by easy to use menus and icons. Mission specific behaviors, such as, stop and observe should be represented as icons that can be associated with a point, line segment or the entire mission plan. Once the mission parameters are established, the high-level goals are translated into an appropriate low-level standard message set and transmitted to the unmanned platform(s) for execution.

Mission planning software should also address constraints. A vehicle being sent waypoints requires on-board navigation hardware and software for localization and for planning the next increment. The tool should be able to capture platform constraints and advise the commander of the ability of a selected platform to accomplish a mission.

This effort should provide capabilities for rapid mission development. A mission translator provides a path for experimentation and mission rehearsal. Users should be able to substitute simulations for actual hardware for mission rehearsal and/or participate in high level simulated war gaming.

PHASE I: Develop a system design that can be used to perform translation from a set of intents to a set of behaviors and atomic actions.

PHASE II: Develop and demonstrate a prototype system for performing translation from a Graphical Mission Plan to control of at least two unique platforms in a realistic scenario. Demonstrated mission plans should include road following, periodic behaviors (i.e. stop and listen), asynchronous behaviors (i.e acoustic sensor triggered, raise mast and survey 360). Phase II must also demonstrate mission rehearsal using simulation for a supported hardware platform.

PHASE III/ DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications where robotic surveillance and tracking are necessary for example, in overseas peacekeeping operations or in enhancing security in industrial facilities. There are also industrial operations, such as warehouse management and construction, as well as agricultural operations.

REFERENCES:
1. "Graphical Mission Specification and Partitioning for Unmanned Underwater Vehicles". Giger, Kandemir, and Dzielski. JOURNAL OF SOFTWARE, VOL. 3, NO. 7, pp 42-54 OCTOBER 2008.

2. "The Joint Architecture for Unmanned Systems, Reference Architecture, v3.3". http://www.jauswg.org/baseline/refarch.html

3. DoD Integrated Product and Process Development Handbook," Office of the Undersecretary of Defense (Acquisition and Technology), Washington, DC 20301-3000, http://akss.dau.mil/docs/02EV001DOC.doc, 09 May 2007.

4. Model-driven Architecture (MDA), Document number ormsc/2001-07-01 Architecture Board ORMSC1 July 9, 2001, http://www.omg.org/mda, 09 April 2007.

5. Smuda, W, Rapid Prototyping of Robotic Systems, Naval Postgraduate School Dissertation, June 2007.

KEYWORDS: Software Engineering, Rapid Prototyping, Robotics, Software Development, Model Driven Design, Joint Architecture for Unmanned Systems (JAUS), Unmanned vehicles, Mission planning