ARMY
12.1 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

INTRODUCTION

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.army.mil.

Solicitation, topic, and general questions regarding the SBIR Program should be addressed according to the DoD Program Solicitation. For technical questions about the topic during the pre-release 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. Specific questions pertaining to the Army SBIR Program should be submitted to:

John Smith
Program Manager, Army SBIR
army.sbir@us.army.mil
US Army Research, Development, and Engineering Command (RDECOM)

ATTN: AMSRD-PEB
3071 Aberdeen Blvd.
Aberdeen Proving Ground, MD 21005-5201
TEL: (703) 399-2049
FAX: (703) 997-6589

The Army participates in three DoD SBIR Solicitations each year. Proposals not conforming to the terms of this Solicitation will not be considered. Only Government personnel will evaluate proposals.

Please note, due to recent changes in SBIR policy, Phase II efforts following a Phase I award resulting from the 11.1 and subsequent Solicitations will have a maximum dollar amount of $1,000,000. Phase II efforts following a Phase I award prior to the 11.1 Solicitation will continue to have a maximum dollar amount of $730,000.

PHASE I PROPOSAL SUBMISSION

Army Phase I Proposals have a 20-page limit including the Proposal Cover Sheets (pages 1 and 2 are added electronically by the DoD submission site---Offerors are instructed to NOT leave blank pages or duplicate the electronically generated cover pages THIS WILL COUNT AGAINST THE 20 PAGE LIMIT), as well as the Technical Proposal (beginning on page 3, and including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents [e.g., statements of work and resumes] and all attachments). Therefore, a Technical Proposal of up to 18 pages in length counts towards the overall 20-page limit. ONLY the Cost Proposal and Company Commercialization Report (CCR) are excluded from the 20-page limit. As instructed in Section 3.5. d of the DoD Program Solicitation, the CCR is generated by the submission website, based on information provided by you through the "Company Commercialization Report" tool. Army Phase I proposals submitted over 20-pages will be deemed NON-COMPLIANT and will not be evaluated. This statement takes precedence over Section 3.4 of the DoD Program Solicitation. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 20-page limit.

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 proposals will be reviewed for overall merit based upon the criteria in Section 4.2 of the DoD Program Solicitation.

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

The Army implements 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 have the Phase I Option exercised. The Phase I Option, which **must** be included as part of the Phase I proposal, should cover activities over a period of up to four months and 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.

COST PROPOSALS

A firm fixed price or cost plus fixed fee Phase I Cost Proposal ($150,000 maximum) must be submitted in detail online. Proposers that participate in this solicitation must complete Phase I Cost Proposal not to exceed a maximum dollar amount of $100,000 and six months. A Phase I Option Cost Proposal not to exceed a maximum dollar amount of $50,000 and four months. The Phase I and Phase I Option costs must be shown separately but may be presented side-by-side in a single Cost Proposal. The Cost Proposal DOES NOT count toward the 20-page Phase I proposal limitation. When submitting the Cost Proposal, the Army prefers the small businesses complete the Cost Proposal form on the DoD Submission site, versus submitting within the body of the uploaded proposal.

Phase I Key Dates	
Phase I Evaluations	January - February 2012
Phase I Selections	March 2012
Phase I Awards	May 2012*

**Subject to the Congressional Budget process*

PHASE II PROPOSAL SUBMISSION

Army Phase II Proposals have a 40-page limit including the Proposal Cover Sheets (pages 1 and 2 are added electronically by the DoD submission site---Offerors are instructed to NOT leave blank pages or duplicate the electronically generated cover pages THIS WILL COUNT AGAINST THE 40 PAGE LIMIT), as well as the Technical Proposal (beginning on page 3, and including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents [e.g., statements of work and resumes] and all attachments). Therefore, a Technical Proposal of up to 38 pages in length counts towards the overall 40-page limit. ONLY the Cost Proposal and Company Commercialization Report (CCR) are excluded from the 40-page limit. As instructed in Section 3.5. d of the DoD Program Solicitation, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool. Army Phase II proposals submitted over 40-pages will be deemed NON-COMPLIANT and will not be evaluated. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 40-page limit.

Note: Phase II proposal submission is by Army invitation only.
Generally, invitations to submit Phase II proposals will not be requested before the fifth month of the Phase I effort. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in Section 4.3 of the DoD Program Solicitation. DoD is not obligated to make any awards under Phase I, II, or III. For specifics regarding the evaluation and award of Phase I or II contracts, please read the DoD Program Solicitation very carefully. Phase II proposals will be reviewed for overall merit based upon the criteria in Section 4.3 of the solicitation.

Invited small businesses are required to develop and submit a technology transition and commercialization plan describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal. Army Phase II cost proposals must contain a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of $1,000,000. 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.

BIO HAZARD MATERIAL AND RESEARCH INVOLVING ANIMAL OR HUMAN SUBJECTS

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.

FOREIGN NATIONALS

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 2.3 of this solicitation for definitions of “lawful permanent resident” and “protected individual”] as key personnel, they must be clearly identified. **For foreign nationals, you must provide technical resumes, country of origin, and an explanation of the individual’s involvement. Please ensure no Privacy Act information is included in this submittal.**

OZONE CHEMICALS

Class 1 Ozone Depleting Chemicals/Ozone Depleting Substances are prohibited and will not be allowed for use in this procurement without prior Government approval.

SBIR FAST TRACK

Small businesses participating 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. See Section 4.5 in the DoD Program Solicitation for additional information.

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

The 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.

Offerors are instructed to include an estimate for the cost of complying with CMRA as part of the cost proposal for Phase I ($100,000 maximum), Phase I Option ($50,000 maximum), and Phase II ($1,000,000 maximum), 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 six Technical Assistance Advocates (TAAs) 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: https://www.armysbir.army.mil/sbir/TechnicalAssistance.aspx.

COMMERCIALIZATION PILOT PROGRAM (CPP)

The objective of the CPP effort is to increase Army SBIR technology transition and commercialization success and accelerate the fielding of capabilities to Soldiers. The CPP: 1) assesses and identifies SBIR projects and companies with high transition potential that meet high priority requirements; 2) matches SBIR companies to customers and facilitates collaboration; 3) facilitates detailed technology transition plans and agreements; 4) makes recommendations for additional funding for select SBIR projects that meet the criteria identified above; and 5) tracks metrics and measures 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 utilizes 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 is 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 https://portal.armysbir.army.mil/SmallBusinessPortal/Default.aspx and is due within 30 days of the contract end date.

ARMY SUBMISSION OF FINAL TECHNICAL REPORTS

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

ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 12.1 Topic Index

Participating Organizations		PC	Phone
Armaments RD&E Center		**Carol L'Hommedieu**	**(973) 724-4029**
A12-001	Electric-Field (Efield) Gunshot Detection System (GDS)		
A12-002	Reserve Cell Technologies with fast initiation for power on demand		
A12-003	A data broker architecture for fires and effects interoperability		
A12-004	Variable Acuity Hemispherical Threat Detection for Remotely Operated Weapons Systems		
A12-005	Low Cost Scalable Technology for Nano Silicon Powder Synthesis		
A12-006	Tunable Reactive Materials for Enhanced Counter Offensive Lethality		
A12-007	Remote Deployment of Explosive Detection Material		
A12-008	Novel Pre-Fire Powering and Data Transfer Links for Munitions		
A12-009	Hovering Tube-launched Micromunition		
A12-010	Shape Changing Maneuverable Munition Using Novel Alloys/Materials for Flight Performance Enhancements		
A12-011	Chlorinated High Energy Density Explosive Materials		
A12-012	Energetic Modification of Aluminum Nanoparticles		
A12-013	Novel Rifle Sight Overlay		
Army Research Laboratory		**Mary Cantrill**	**(301) 394-3492**
A12-014	Novel Gun Barrel Rifling Technology		
A12-015	Miniature Infrared Hyperspectral Imager		
A12-016	High Efficiency Generator Set with Integrated Energy Recovery		
A12-017	Tunable Stiffness Thorax/Mechanism for Flapping Wing MAV		
A12-018	Fabrication of functionally graded fine grained magnesium alloys for structural applications		
A12-019	Real Time Structural Health Monitoring of High Velocity Impact Events		
A12-020	Wings and Propulsion for MAV Gust Rejection		
A12-021	Optimizing the use of atmospheric energy to extend range and endurance of low altitude UAVs and small manned aircraft		
A12-022	Surface Engineering Technologies for Improved Gear Efficiency		
A12-023	Solid Acid Electrolyte Fuel Cell		
A12-024	Dislocation reduction in LWIR HgCdTe epitaxial layers grown on alternate substrates		
A12-025	Tools for Adapting Computer Based Tutors to Commercial Games		
A12-026	Tools for Rapid Automated Development of Expert Models (TRADEM)		
A12-027	Data-Driven Architecture To Support Adaptable Training Systems		
A12-028	Analytical Decomposition Capability To Support Live, Virtual, Constructive and Gaming Execution		
A12-029	Biomimicry Based Azimuth Sensing		

Communications Electronics Command **Patricia Thomas (443) 861-7587**

A12-030	Controlled Mobile Agents
A12-031	Automatic Spoken Language Recognition for Machine Foreign Language Translation (MFLT)
A12-032	Mitigation of Range/Doppler Straddle for Radar Coherent Processing
A12-033	Tactical Interference Cancellation Equipment (TICE)
A12-034	Real-Time Handling and Planning System for Operational Decisions (RHAPSODy)
A12-035	Helicopter Hostile Fire Indicator (HFI) Sensor Development
A12-036	Enhanced Operator Situational Awareness for Multi-Unmanned Vehicle Teams
A12-037	High Speed and Low Operating Voltage Laser Q-Switch
A12-038	Extended Range Low Power Personnel Detection and Classification Sensor
A12-039	Electroless Plating of Indium Bumps for High Operating Temperatures (HOT) Mid-Wave (MW) Sensors
A12-040	Novel Approaches to Buried Explosive Hazard (BEH) Detection using Electromagnetic Techniques
A12-041	Advanced Order Linearizer for Satellite Communications
A12-042	Variable Magnification Clip-On Thermal Imager (COTI)
A12-043	Context Independent Anomaly Detection for Enhanced Decision Making
A12-044	Intelligent PMESII Information Management Workbench
A12-045	Improved Mobile User Objective System (MUOS) Metaferrite Based Antenna for SATCOM
A12-046	Embedded Co-Located Antenna Elements to Increase Pattern Coverage and Effectively Mitigating Interference for Improved Communications
A12-047	Resources Management in Peer-to-Peer Mobile Ad Hoc Network Communications Environments
A12-048	Advanced Small, Lightweight Multi-Fueled 1,000 - 1,500 W Variable Speed Load Following Man-Portable Power Unit

Edgewood Chemical Biological Center **Dhirajlal Parekh (410) 436-8400**

A12-049	Novel Methods To Develop Graphene Obscurant Materials
A12-050	Novel method for filling graphite microfibers

Natick Soldier RD&E Center **Arnie Boucher (508) 233-5431**
Cathy Polito (508) 233-5372

A12-051	Wind Energy Systems for Base Camp Applications
A12-052	Novel Textiles for Use as Friction Buffer on Parachutes
A12-053	Design Tool for Electronic Textile Clothing Systems
A12-054	Development of Lightweight, Recyclable Low Cost, Nonwoven Cloth Duck Material

PEO Ammunition **Vince Matrisciano (973) 724-2765**

A12-055	Non-Toxic, Non-Incendiary Obscurant Smoke for Ammunition and Munitions
A12-056	Innovative Solutions for Propellant Temperature Sensing for Future Munitions

PEO Combat Support & Combat Service Support **Heather Gruenewald (586) 282-8032**

A12-057	Launch-able Tagline and Remote Anchor System
A12-058	Fatty Acid Methyl Ester (FAME) Portable Detection Device for Fuel Contamination (JP-8, Jet, and Diesel)

PEO Ground Combat Systems **Peter Haniak (586) 574-8671**
Jim Muldoon (586) 770-3513

A12-059	Occupant Sensor Suite for Blast Events

PEO Intelligence, Electronic Warfare & Sensors **Bharat Patel (410) 273-5484**
Todd Simkins (443) 861-7823

A12-060	Standoff Counter Human Deception Detection Device
A12-061	Secure GPS Sensor Platform (GPS-SP) for the Handheld Computing Environment

PEO Missiles and Space **George Buruss (256) 313-3523**
Carol Tucker (256) 876-5372

A12-062 Innovative Rugged High Power RF Sources for Compact RF Warheads

PEO Simulation, Training and Instrumentation **Robert Forbis (407) 384-3884**

A12-063 Autonomous Trackless Vehicle Target
A12-074 Haptic Feedback for a Virtual Explosion

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

A12-064 Multi-Pulse Single Shot Explosive Power Supplies
A12-065 Novel Concept for Mapping Out No Fire Zones for a Scalable Effects High Power Laser System with a Multi-Mission Capability
A12-066 Pulse Power and Energy Sources for High Power Microwave and High Power Laser
A12-067 Nanosatellite to Standard Army Handheld Radio Communications System

Tank Automotive RD&E Center **Martin Novak (586) 282-8730**

A12-068 Sulfur Tolerant Solid Oxide Fuel Cell (SOFC) Stack
A12-069 Integration of computational geometry, finite element, and multibody system algorithms for the development of new computational methodology for high-fidelity vehicle systems modeling and simulation
A12-070 Efficiency enhancement in a unmanned/robotic vehicular system based on drive cycle and driving pattern prediction
A12-071 Force and Moment Tire Characterization
A12-072 Development of affordable high-performing passive exhaust systems and manufacturing technology
A12-073 Stability Control Improvement and State Detection for Autonomous Vehicles

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 **$100,000** with up to a six-month duration) AND (if applicable) an optional effort (up to **$50,000** for an up to four-month period to provide interim Phase II funding).

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

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

____ 4. **Army Phase I Proposals have a 20-page limit including the Proposal Cover Sheets (pages 1 and 2 are added electronically by the DoD submission---Offerors are instructed to NOT leave blank pages or duplicate the electronically generated cover pages THIS WILL COUNT AGAINST THE 20-PAGE LIMIT), as well as the Technical Proposal (beginning on page 3 and including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents [e.g., statements of work and resumes] and all attachments). Therefore, the Technical Proposal up to 18 pages in length counts towards the overall 20-page limit. ONLY the Cost Proposal and Company Commercialization Report (CCR) are excluded from the 20-pages. As instructed in Section 3.5, d of the DoD Program Solicitation, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool. Army Phase I Proposals submitted over 20-pages will be deemed NON-COMPLIANT and will not be evaluated. This statement takes precedence over Section 3.4 of the DoD Program Solicitation. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 20-page limit.**

____ 5. The Cost Proposal has been completed and submitted for both **the Phase I and Phase I Option** 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 (offerors are instructed to include an estimate for the cost of complying with CMRA).

____ 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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A12-067	Nanosatellite to Standard Army Handheld Radio Communications System
A12-068	Sulfur Tolerant Solid Oxide Fuel Cell (SOFC) Stack
A12-069	Integration of computational geometry, finite element, and multibody system algorithms for the development of new computational methodology for high-fidelity vehicle systems modeling and simulation
A12-070	Efficiency enhancement in a unmanned/robotic vehicular system based on drive cycle and driving pattern prediction
A12-071	Force and Moment Tire Characterization
A12-072	Development of affordable high-performing passive exhaust systems and manufacturing technology
A12-073	Stability Control Improvement and State Detection for Autonomous Vehicles
A12-074	Haptic Feedback for a Virtual Explosion

Army SBIR 12.1 Topic Descriptions

A12-001 TITLE: Electric-Field (Efield) Gunshot Detection System (GDS)

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics

OBJECTIVE: Design, develop, and demonstrate the electric-field (E-field) gunshot detection system (GSD) for vehicular and dismounted operations to perform direction detection, range to and elevation of shooter/target location. Multisensor data fusion with other gunshot detection systems will be investigated for multi-modal operation.

DESCRIPTION: Gun fired bullets and projectiles passing through open-air regions carry an electric charge which can be sensed by an electric field (E-field) detector to determine direction of travel. A gunshot detection system that would work in a wide variety of operational scenarios such as silenced guns, subsonic bullets, mountainous terrain, urban environments, multiple shooters and high background noise is highly desirable. ARDEC and Army Research Laboratory have pioneered pursuing this innovative technology for counter sniper gunshot detection capability. ARDEC has performed extensive local tests verifying this potential technology for accurate bullet detection of single and multiple gunshot events at short and extended ranges with full automatic fire, silencers, and sub sonic rounds. Our independent testing verified the E-field GSD can achieve the following performance objectives: 1) a lightweight vehicle mounted counter sniper GSD that rapidly and automatically detects bullets; 2) precisely measures and calculates the azimuth angle, range, and elevation of shot origination; 3) measures the speed of the detected bullet; 4) multisensor data fusion with existing systems; and 5) function as a stand-alone for dismounted situational awareness of a static position. The E-field GSD is a passive system and capable of functioning as a stand-alone if other detector(s) are degraded and/or eliminated; perform detections across 360 degrees of coverage (multi-shot, multi-location, ambush, multi-elevation scenarios); and for all fired weapon threats to include those from handguns, pistols, battle rifles, sniper rifles, machine guns, assault guns, RPGs, and larger caliber rounds (>14.75mm direct fire). These threats represent supersonic and sub-sonic velocities, and capability for silenced shots (using silencers). The E-field GSD performs in high reverberation (acoustic) environments such as MOUT (Mounted Operations in Urban Terrain), and other tactical test scenarios containing high battlefield acoustic background noise.

PHASE I: Develop a feasibility study of an overall design for a tactical vehicle E-field GSD system that includes specifications of the E-field sensors array. Data needs, test needs, design trades, and performance/exit conditions shall be explored. Since an optional dismounted capability is desirable for "defensive outpost", designs will look at on vehicle/off vehicle manageable assembly.

PHASE II: Develop and demonstrate in a relevant environment a prototype E-field GSD system on a tactical vehicle under routine small arms live fire testing. All system hardware (H/W), software (S/W), and results will function in real time. Performance requirements will demonstrate bullet detection and bearing within 0-30 meters from detectors, 360 degree detection in azimuth, and 0-90 degrees in elevation. If the dismounted option for "defensive outpost" is not the same as its vehicular configuration, its' functionality will likewise be demonstrated and tested.

PHASE III: Upon completion of a successful demonstration of the prototype system, the E-field GSD technology would be further developed for tactical vehicular optimization and soldier/user testing at Aberdeen Proving Grounds. The counter-sniper algorithms, software, and hardware developed under this effort shall have dual use applications for all levels of law enforcement and other government agencies for Homeland Defense. This system will be extremely useful in urban environments where high background noise may be encountered. Local and county police organizations that supported ARDEC in testing this technology have expressed great interest in its development and availability for police cars, and individual officer options.

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KEYWORDS: Counter sniper, sniper detection, Gunshot Detection System, gunfire detection, bullet detection, projectile detection, rocket launch detection, situational awareness, battlespace awareness.

A12-002 TITLE: Reserve Cell Technologies with fast initiation for power on demand

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: The proposed project aims at developing new energy storage devices that can be initiated using new methods for near instantaneous initiation of the power source in munitions and to provide power on demand for the development of new energy management techniques.

DESCRIPTION: The proposed project aims at developing new reserve energy storage devices with new energy management architectures and novel methods to be initiated either using the launch forces or that can be electrically initiated with programmable features to fit application missions. Prior to activation, the energy storage system remains in a quiescent state with minimal self discharge, power drain or leakage. Activation may occur via remote control or various triggering mechanisms, thus providing the stored energy only when needed. Once initiated, the energy storage system must provide ultra fast initiation characteristics to full voltage. Initiation to full voltage must occur with a goal of less than 3 msec at full load. The novel electrochemical architecture can be scaled to be integrated on a semiconductor chip, as an example integrated into sensor electronics or could be scaled up in similar configurations as legacy thermal or liquid reserve batteries. The distinct differences would be the new power on demand (less than 3 msec) and new architecture configurations as compared with legacy reserve technologies that typically take much longer for initiation (more than 150 msec).

Shelf life of the preferred designed devices must exceed 20 years and the temperature performance of the energy storage system must meet all military operational and storage temperature requirements. Additionally, the battery must operate and meet application power requirements at low and high spins and during high launch and flight vibration. The energy devices being sought by this topic must be scalable, miniaturizable and must be safe to operate across the harsh environments produced by military applications. Given the need for electronics miniaturization, a path towards power source integration with electronics must be identified. Re-use of materials, commonly found in electronics manufacturing and packaging (e.g. Cu, Al, Si, PCB) is highly encouraged.

PHASE I: Study various miniaturizable reserve battery approaches, which may include engineering and modeling simulations, to develop a strategy for achieving the best possible architecture for footprint, triggering characterization, battery chemistry and other internal components, to meet power and application objective of topic. At the conclusion of phase 1, a selected design meeting the power requirements of a host application would have to be proven feasible, in order to be ready to advance to a phase II.

PHASE II: Build full-scale reserve storage prototypes and test in relevant environments, including simulated launch events. Demonstrate that prototypes can survive in operational environments while providing voltages and power requirements under simulated load conditions. Produce final prototypes of each design that meets power requirements mentioned in the description, conduct air gun tests and validate performance.

PHASE III: The objective goals of this SBIR project is the insertion of this new scalable smart reserve energy storage devices into various applications for small and medium power requirements. Examples of these applications would be 30 mm munition applications that require highly miniaturized power sources and relatively small amounts of energy in the order of 20 to 50 mJ. In addition there are medium power applications with large launch accelerations (80 KGs) that would be required to integrate these energy storage devices.

Develop a manufacturing plan for transitioning from prototypes to low rate initial production. Possibility for application not limited to the area of munitions and could include power sources for remote sensor network devices, emergency memory back up for computer systems, and power sources for anti-tampering electronics.

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KEYWORDS: Fast initiation less than 3 msec, power on demand, novel electrochemical architectures, programmable features, minimal self discharge

A12-003 TITLE: <u>A data broker architecture for fires and effects interoperability</u>

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

OBJECTIVE: Design, develop and demonstrate a data broker architecture and implementation to enable fires and effects information exchange, semantic understanding, and data interoperability between Command and Control (C2) devices, Modeling and Simulation (M&S) systems, and autonomous vehicles/platforms. The objective of this research is to provide a means to achieve seamless interoperability between these three domains of activities to achieve greater operational effectiveness for the future warfighter.

DESCRIPTION: Advances in technology will soon have Command and Control (C2) devices, M&S systems, and autonomous platforms interacting and communicating on the future battlefield to provide unprecedented capability to the warfighter. The key to the successful employment of these systems is seamless interoperability and understanding between systems at the basic data level without the need for human intervention. For this level of interoperation to be successful it is imperative that semantic understanding of data, specifically tasks and orders, and their associated contextual information is unambiguous between all systems. Current C2 devices, M&S applications, and autonomous platforms continue to operate using their own unique message formats and communication protocols. The trend of integrating M&S applications into the battlefield decision making process will continue as software tools mature providing course of action development and analysis, mission rehearsal, and support to remote training. These tools will need to understand mission orders and tasks and also account for the capabilities and interactions with autonomous platforms. It is clear that the role of autonomous platforms will continue to become more important to mission effectiveness and the safety of future warfighters. The battlefield is still controlled by C2 devices so the interoperation and clear understanding of software applications (M&S systems) and unmanned platforms is critical to achieving this vision. Use of a data broker architecture approach will provide the means to enable unambiguous data interoperability between different domains of systems. While this research will focus on operational fires and effects the approach to this type architecture will be extendable to any of the warfighter functional areas.

PHASE I: Investigate innovative methodologies to achieve true seamless, automated information exchange between the domains of systems identified in the project description. Develop an architecture for fires and effects interoperability and an implementation design of a data broker to mediate the data transfer between systems. Demonstrate a proof of principle of the architecture and implementation using a representative subset of data messages.

PHASE II: Develop and demonstrate a prototype capability that can be inserted into a realistic, ARDEC-supplied fires and effects architecture. The prototype data broker implementation must be capable of seamless integration and operation within the ARDEC-supplied architecture. Conduct testing to demonstrate feasibility of the data broker and architecture for operation within a combined live C2, simulation environment, and live autonomous platform operated by ARDEC.

PHASE III: The architecture and software developed under this effort can be extended to Joint service fires and effects integration and will have dual use applications in domestic security operations. Homeland Defense operations could use this capability to support interoperability with non-governmental command, control, and emergency response systems in responding to security incidents or natural disasters.

REFERENCES:
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KEYWORDS: data broker, interoperability, fires and effects, M&S, autonomous vehicles

A12-004 TITLE: Variable Acuity Hemispherical Threat Detection for Remotely Operated Weapons Systems

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop and fabricate a hemispherical threat detection system that provides variable range and resolution throughout the hemisphere for remotely operated weapon systems.

DESCRIPTION: A significant gap exists in currently available technology in the number of targets that can be interrogated simultaneously with variable acuity and in automatic or semiautomatic discernment of "normal" from "unusual."

This effort will develop, fabricate, and implement a system appropriate for integration with remotely operated weapons systems that provides controlled variable perception, both in resolution and range, throughout the hemispherical space. The system should, based on a detection of particular phenomenon at low resolution, semi-automatically increase its acuity in particular directions or cones of operation to further refine the detection of the phenomenon, provide the data to the user with a warning of the type of phenomenon, and its level of danger to the user. The system design should be appropriate for both stationary site mounting and vehicle mounting. The system should understand and comprehend "normal" effects for the environment in which it is operating and differentiate "normal" from "unusual" and cue the operator to the presence and direction of the source of unusual effect. The system should automatically or under user control increase the spatial acuity in the cone or cones of reception of the unusual signal, increasing detection capability to identify the event and its potential threat level. The system should allow screening and tracking of a wide area for potential threats and then focus on regions of interest to determine the nature of the threat.

PHASE I: Design the threat detection system, identify the hardware processor and sensory components, identify and elaborate on the method of analysis of the sensory output, means of integration with remote controlled weapons, identify and elaborate on the method for continuously learning the system environment in order to differentiate between "normal" events and "unusual" events, provide a top level design for the system as a whole, and establish the relative capability of the components chosen over alternatives. The Phase 1 proposal should elaborate on what constitutes "normal" and the acuity necessary for its determination, understanding that normal conditions vary with environment, time of day, weather, etc.; this definition will be further refined in the Phase 2 proposal. The system design must be for hemispherical coverage. Hence, "normal" will differ with elevation and possibly azimuth. To decrease transmission bandwidth, discernment processing should be done at the site of detection with pertinent and sufficient information flowing forward for a crew served decision.

PHASE II: Build a bench-level prototype. Acquire data using the prototype for many scenarios, both civilian and military in nature, and use the data to design and program real-time capable analysis for separation of "normal" from "unusual" events. The prototype must detect the cone regions containing the sources of the events, increase the acuity for those regions, reanalyze the event to establish a "danger", and report in real time the cause of the event, its danger level, location, and sufficient evidence for a crew member to make final decision as to how to response to the event.

PHASE III: The product of this solicitation will be a key component in the war on terror, providing "smart situational awareness" for remotely operated weapon systems at stationary sites, on manned vehicles, or on unmanned systems. Because processing is done within the system, bandwidth to a central site can be greatly reduced. During Phase 3, the contractor should develop multiple ruggedized prototypes, TRL 6, and arrange for their field testing and evaluation. Commercial applications would include Computer Integrated Manufacturing, civilian security systems, filmmaking, electronic games, and agricultural automation.

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3) Research Challenges in Combating Terrorist Use of Explosives in the United States. Subcommittee on Domestic Improvised Explosive Devices. DEC 2008.

4) Detection and Tracking with a Hemispherical Optical Sensor Tracker (HOST). SPIE 5430 April 2004

KEYWORDS: Hemispherical target detection, crew served weapons, situational awareness

A12-005 TITLE: Low Cost Scalable Technology for Nano Silicon Powder Synthesis

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Develop a cost effective technology that can produce large quantities of high purity, nano-scale silicon powder. The technology should have control over the desired particle size and morphology of the powder.

DESCRIPTION: The U.S. Army has a need for cheap, high quality nano silicon powder. It has been shown that by using nano-scale fuels and oxidizers, more complete reactions can be achieved. This is primarily a result of the increased surface area achieved at the nano-scale. For this reason, traditional metallic fuels such as aluminum are being examined on the nano-scale, with impressive results. Silicon has a similar energy density to aluminum and is a natural extension of nano aluminum research. By using nano silicon as a fuel, similar performance to nano aluminum mixtures can be achieved but with different burn characteristics due to silicon's higher initiation temperature. But more importantly, silicon is not prone to some of the major problems that detract from the potential uses of nano aluminum. Nano silicon is not susceptible to the rapid aging effects observed in nano aluminum, so mixtures using nano silicon will have a much better shelf-life. In addition to the better stability, nano silicon is also easier to handle than nano aluminum – the passive oxide layer is thinner than aluminum’s and subsequently is easier to process. It is also important to note that silicon’s higher initiation temperature (as compared to aluminum) makes it less sensitive to accidental initiation. Thus nano silicon has the potential to be a safer, more stable alternative to nano aluminum.

The military and commercial uses for nano silicon are rapidly growing, but the high cost of the powder severely restricts its use to ultra high value applications. With current domestic prices on the order of several thousand dollars per kilogram, the need for a cheap, innovative process to produce nano silicon powder is critical. It should be noted that the demand for nano silicon is currently unknown but for successful incorporation into Army items, the material cost must be drastically reduced.

PHASE I: Develop a semi-continuous process that can produce 98-99% pure silicon powder with a surface area in the range of 32-50m^2/g, an average particle size less than 80nm, and a volumetric d90 = 100nm at a cost of no more than $200/kg. A surface area of 32m^2/g typically corresponds to an average particle size of 80nm for spherical Si, however the particle size distribution may be very broad. It is important that the particle size distribution be fairly tight for incorporation into nano silicon based compositions for energetic applications. The process must be amenable to synthesizing the silicon powder free of hard agglomerates, preferably with a spherical morphology. Synthesis rates should be on the order of 1-5kg/day.

PHASE II: Optimize the process developed in Phase I to produce greater than 99.9% pure silicon powder with a surface area in the range of 32-50m^2/g, an average particle size less than 80nm and a volumetric d90 = 85nm at a cost of no more than $50/kg. Synthesis rates should be on the order of 50kg/day.

PHASE III: The material developed under this effort will have a myriad of applications in the military as well as the commercial sector. Such uses include novel energetics/pyrotechnics as well as low cost electronics. Through the use of a nano silicon suspension, cheap/disposable devices can be fabricated through manufacturing technologies such as ink-jet printing. Such technology will bring a new level of capability to military as well as commercial consumers. Thus, the ultimate objective is a continuous process capable of producing electronics grade nano silicon at a cost of approximately $25/kg or less.

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KEYWORDS: silicon, nano, low cost process, powder, synthesis

A12-006 TITLE: Tunable Reactive Materials for Enhanced Counter Offensive Lethality

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design, develop and demonstrate structural reactive materials that can be tuned for the defeat of improvised explosive devices, munitions, and structures.

DESCRIPTION: The U.S. Army is seeking new and highly innovative approaches to significantly enhance the ability of reactive material items such as shape charge liners and breaching charges to provide precision demolition for IED threats and structure entry. These materials will provide enhanced precision and effectiveness against current and future threats.

Reactive shaped charge liners are seen as a next generation approach to IED defeat due their ability to penetrate both armor and earth to create regions of high temperatures and pressure within a buried or protected IED. They attain higher velocity than conventionally launched projectiles providing unrivaled armor piercing capability. The high terminal reaction temperatures are effective at defeating high explosives and enhance destruction of chemical/biological agents. Also, the structural properties allow for reduced size, weight, and volume of the charge/projectile which has a multiple-compounding effect of reducing propulsion requirements and thus total system weight, size and complexity. Another advantage is the ability to tune the amount of energy released by the liner by adjusting the structure and composition during processing. This will allow for tailored liners enhanced for certain applications like earth penetration or wall breaching.

The main purpose of this effort is to study and improve the material development of reactive liners, define the chemistry involved in the reactive jets, and describe the reactions with selected targets. The thrust of the program will be based on: (a) the selection of high density reactants (based on thermo-chemical and physical properties), (b) liner manufacturing techniques, (c) chemical and physical characterization to define level of reactant mixing uniformity and the energy release, both measured and calculated.

PHASE I: Investigate innovative reactive material systems that can be applied to the fabrication of reactive shaped charge liners. Density should range from 9g/cc to 16g/cc, mimicking the density of current inert shape charge liners. The exothermic reaction upon activation should attain temperatures greater than 2,000K. Some systems currently being investigated have produced 7.8g/cc maximum density and 1,900cal/gram energy density. The goal is to improve upon these results. Structural requirements dictate that strengths must match the inert materials it is replacing at a given density, i.e. Copper, Molybdenum and Tantalum. It will be necessary to document potential material systems along with the justification for the choice of those systems and evaluate tenability of processing and chemistry. It will also be necessary to demonstrate the fabrication potential of each system and provide initial reactive material performance data. A successful contractor will provide test data showing that their materials exceed the performance of inert material in military standard shaped charge applications. Phase I requirements are: 1) Density of 9-16g/cc, 2) Energy density of 2-7Kcal/g, 3) Strength greater than 50Ksi.

PHASE II: During this phase, compositions will be optimized to develop full scale reactive shaped charge liners, explosively formed penetrators, or any other desired configuration as desired by the application. The contractor will provide 50 pieces within the specifications outlined in configurations supplied by ARDEC, in each of three iterations. Each iteration will be used to validate the tunability (ARDEC configurations will range from non-lethal to lethal applications) of these compositions. All of the products made must also pass Insensitive Munitions tests as defined in MIL STD 2105C. Configurations will support current and future Army Technology Objectives (ATOs) such as Advanced Warheads for Scalable Effects Munitions (AWSEM) and Extended Area Protection Systems (EAPS). This phase will deliver performance data to supplement modeling efforts and produce a complete technical data package. Data will include density, energy output, and strength.

The performance related goals will focus on steel and copper analogs (compositions with density on the order of 9g/cc) in year one and tantalum analogs (density on the order of 16g/cc) in year two. While the energy density will vary depending on the material constituents, the products developed in year one must have a minimum energy density of approximately 4Kcal/g, and 2Kcal/g for the higher density materials in year two, as density is typically increased at the expense of energy density. Optimized compositions should have strength on the order of 75Ksi.

PHASE III: Provide liners in sufficient quantity for field trials, acquire relevant safety data to address DoD component shipping, handling and storage requirements and provide information to a modeling effort to further develop a simulation capability for future lethality modeling.

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KEYWORDS: reactive shaped charge liners, IED defeat, chemical/biological warfare, reactive materials, explosive defeat

A12-007 TITLE: Remote Deployment of Explosive Detection Material

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: To use existing ammunition deployment systems to provide a delivery vehicle for stand-off detection of explosives using a powder or liquid identification material.

DESCRIPTION: Research has been successful in developing identification materials that detect and categorize explosive materials. These identification materials can come in liquid or powdered form, and change color on contact with bulk or trace amounts of explosives. While this offers the user the ability to detect explosive material, it requires the user to come within close proximity of the material, thereby placing them in harm's way if the material explodes. It would be desirable to have the capability to dispense the identification materials from a distance, and have it arrive at the material one wishes to interrogate.

Paintball markers are currently being used to dispense marking paints, dyes, and crowd control irritants. These systems utilize a 3 gram, .68 caliber ball that moves at over 300 feet per second, and dispense 2.5 mL of material on the target over a 3 inch square area. While this may be suitable for close range marking, the volume and marking pattern is not adequate to be visible at longer ranges. Paintballs are also spherical and deployed from a smooth bore tube, restricting its stability over longer distances. The FN303 is a less-than-lethal weapon that is similar to a paintball, but solves many of its shortcomings. It is spin stabilized, and travels at a much higher velocity. While this device is capable of hitting targets at longer distances, it contains too small of a volume to produce the visible effects desired in this SBIR when viewed with bare eyes at long ranges.

To solve this problem, one must come up with a solution that is accurate over long ranges, and is capable of dispensing a modest amount of material over a large area on a target. The aerodynamics of the projectile should be proven to be stable through analysis, and the results proven through testing. This will minimize safety issues that can arise in both energetic and inert projectile approaches. The marking pattern should maximize the area covered by the mark, while minimizing the impact, shock, or heating of the target.

We wish to use existing weapons systems to mark a target, as it would minimize the amount of equipment required to accomplish the task and reduce the manpower impact for training and familiarization with the equipment. The system should deliver a projectile from a hand held weapon system. The delivery projectile must exhibit low impact energy so as to not set off the explosive material at ranges between 50 and 100 meters. The projectile should demonstrate accuracy at standoff ranges up to 100 meters, while maintain a 90% probability of hitting a 2’ x2’ cross sectional target using a hard mounted weapon. The projectile should be able dispense its identification material over at least a 25 square inch target area with enough coverage to be visible without magnifying optics at distances up to 100 meters.

PHASE I: Provide a detailed description of proposed projectile and launching system. As accuracy and impact forces are important, one should provide a proof of concept through detailed analytical work. The analysis shall prove the concept capable of being able to meet stability requirements in launch and flight to meet the accuracy described. The analysis shall demonstrate the capability to hold enough volume liquid or powder to cover the target area described adequately. The analysis shall demonstrate the capability of the projectile to dispense the identification material over a 25 square inch area, while maintaining a non-lethal scale impact force on target.

PHASE II: This phase should bring the concept described in Phase I through TRL6. An explosive identifying material should be selected. If necessary, the properties of the explosive identifying substance should be modified to optimize the marking pattern on the target. This may include adjusting the viscosity, granularity, or concentration of the substance. The projectile must prove that it can successfully meet the design criteria established for accuracy, impact energy, and pattern scatter. A small number of rounds should be manufactured and filled with an explosive detection substance for testing. A marking substance should be developed with similar physical properties to the explosive detection substance, which will be capable of marking the target in a similar pattern. If possible, the rounds should be tested through a gun fired test at a private or government range. At a minimum, an air-gun or simulated launch shall be performed on the round.

PHASE III: This phase of the program should complete the design concept into a production ready projectile. If not completed in Phase II, a live fire test shall be performed. A small production run of 400 explosive detection rounds should be completed for military testing. The system manufacturing and assembly process should be streamlined. Training rounds and mass simulated rounds should be produced.

After proving the ability to disperse an explosive detection agent, the ability to accurately disperse materials at long ranges can be applied to solve other military and civilian needs. The munition could be filled with irritants for use as a riot control measure. If filled with a marking agent, the system could be used to mark suspects during riots. In search and rescue, the marking munition could be used to mark trees, ledges, or other inaccessible surfaces that would aid in aerial identification and localization of a lost person. The system could be used by airborne assets to mark areas necessary for inspection by personnel on the ground. These concepts should be explored, and the munition design should be compatible with a variety of fill materials for these purposes.

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KEYWORDS: explosive detection, projectile, small arms, medium arms, ammunition, small caliber, medium caliber

A12-008 TITLE: Novel Pre-Fire Powering and Data Transfer Links for Munitions

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

OBJECTIVE: Develop novel wireless methods and devices for pre-fire powering of munitions and for establishing data transfer links to load firing information. This effort is requesting technical proposals for developing the capability to transfer large amounts of energy and high speed data using contactless methods. The proposed novel concepts should be suitable for in-breech and/or out-of-breech applications.

DESCRIPTION: The primary purpose of this SBIR project is the development of new concepts that are uniquely suited for wireless rapid charging of on-board capacitors and establishment of data transfer links with the on-board electronics. The proposed concepts must be suitable for application to a wide range of munitions, including small and medium caliber munitions in addition to the larger caliber rounds. The proposed concepts must yield devices that occupy minimal volume in munitions.

Currently, smart/guided munitions use reserve power supplies which are initiated during launch or during flight. This means that during the initial phases of the deployment of munitions, power is not available since the reserve power supply has not been initiated. Most current munitions as well as future smart/guided munitions and fuzing systems require the loading of firing data, which requires electrical power inside munitions to receive and store firing data and requires the transferred data to be held until the main reserve power source is initiated after launching the munition. Currently, three main methods are used to address pre-firing power requirements. The first method relies on contacts, usually in the breech, to charge onboard capacitors and download firing data. The second method relies on induction coils inside the breech to charge onboard capacitors and download firing data. The third choice is the use of chemical batteries. However, primary batteries suffer from shelf life and operating temperature limitation problems and reserve batteries suffer from being for one-time and limited-time use only. For the case of breech contacts and induction coils, they have been and are being used in munitions, however, both methods suffer from operational problems, particularly field problems that directly affect warfighter’s capability to carry out missions. Both these methods, particularly those involving contacts require frequent cleaning and maintenance. This is particularly the case for contacts since poor and dirty contacts means not enough power and ineffective means of transferring firing data to the munitions. For the case of induction coils, this method cannot meet data rates and power transfer rates needed to meet future pre-launch power requirements for smart/guided munitions. For the case of rockets and missiles, umbilical cords have to be used for initial charging and data transfer prior to firing. Umbilical cords are also used for diagnostics and other similar purposes. The main problem with umbilical cords is that they are cumbersome in the field and have to be connected and disconnected for firing and diagnosis.

The work to be proposed needs to provide solutions to achieve complete and rapid transfer of data and charge of an existing munitions re-usable power source. The project needs to concentrate on the functions of power and data transfer to eliminate current methods of transferring power and data. The firing data transfer is to be integrated into the charging system with the option of providing separate stations for charging munitions re-usable power sources and for firing data transfer capability.

Furthermore, proposals must address the elimination of some on-board active batteries and the problems associated with such batteries, including safety and shelf-life requirements of up to 20 years and potentially eliminating these types of munition power sources. Proposals must address the ability to transfer small to very large power and data rates. Data rates of 16Mb/sec should be considered and power transfers of 100watts /sec should be considered as a minimum. In most munitions, both charging and data transfer has to be completed in a few seconds. For the reasons of maintenance, weapon platform design issues and other related problems with the electrical contact and induction coil designs, it is highly desirable to develop wireless connections for rapid charging of capacitors on-board munitions and establishment of data transfer links for transmitting vital targeting data and firing information to the on-board processors inside the projectile.

PHASE I: Develop novel methods and devices for pre-fire powering of munitions and for establishing data transfer links for loading targeting data and firing information. Develop analytical and/or numerical models for determining the feasibility of each developed concept and simulate its performance in terms of the potential rate of power transfer and data transfer rate.

PHASE II: Finalize the modeling and simulation efforts and develop a method for optimal design of the components of the wireless capacitor charging and data transfer link system. For the selected munitions, design and fabricate a pre-fire powering and data transfer link system based on the method selected as a result of the Phase I efforts. Develop a method and related hardware and software for testing the performance of the fabricated system in terms of the rate of energy transfer and the rate of data transfer and the robustness of the system. Design and fabricate final prototype based on the results of the laboratory tests for the selected munitions and for potential Phase III efforts.

PHASE III: The development of novel wireless rapid capacitor charging and data transfer link systems for pre-fire powering of munitions and for establishing data transfer links to load targeting and firing information that are cost effective and occupy minimal volume is essential for the development of cost effective smart and precision munitions. The developed system will also have a wide range of dual use homeland security and commercial as well as other military applications. On the military side, the system may be used on UAVs, sub-munitions, guided flairs and other guided and precision munitions. In the areas of homeland security, they can be used on low and high-flying UAVs, air dropped guided reconnaissance or sensory platforms as well as their commercial counter parts.

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KEYWORDS: Keywords: Munitions, data transfer, weapon systems, guided, precision, artillery, mortars, power, capacitor

A12-009 TITLE: Hovering Tube-launched Micromunition

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Weapons

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

OBJECTIVE: Design, develop and demonstrate a micromunition concept which will have the ability to hover/loiter by using propulsion and glide for lift enhancement. This munition shall be housed in and expelled from a carrier munition such as mortar round or a 40 mm M433 grenade. The munition will initiate flight in midair, self correct in roll, generate lift, and enhance range.

DESCRIPTION: The US Army seeks to expand its capabilities in urban warfare by gathering enemy intelligence prior to advancing into enemy territory. The Hovering Micromunition will have the capability to hover/loiter for at least 10 minutes, travel at least 1 km, survey enemy targets by using a miniature day/night camera system, enter enemy buildings, and provide GPS coordinates of enemy locations. The system will be launched from a mortar tube or the M320 launcher, and the micromunitions will be expelled from the carrier airframe or casing to commence flight in midair.

The development of such a concept will be critical in future missions to provide valuable intelligence for the US soldier and at the same time ensure the safety of the warfighter through a lethal response. The Hovering Micromunition shall be affordable, lightweight, and G-hardened to endure the harsh environments from the mortar tube and launcher. Space should be allocated on the micromunition for a lethal payload.

PHASE I: Investigate a micromunition design solution by conducting a finite element analysis to validate the structural integrity of all components of the micromunition airframe, since the system will be launched at a maximum level of 15,000 Gs. Provide a preliminary study of the propulsion system and predict the aerodynamics for the design concept. Investigate camera and sensor components for guidance and navigation.

PHASE II: Refine the predicted aerodynamics of the micro-munition concept and conduct wind tunnel testing. Implement wind tunnel data into a six degree of freedom simulation and begin trajectory simulations to evaluate performance, range and manueverability. Develop the guidance control and navigation software and a hand-held control system for the munition. Test the propulsion system through bench tests to validate simulations. Conduct high-G testing of components. Run additional flight simulations with guidance and control algorithms in preparation for future flight tests. Demonstrate transmission of GPS and video data in a laboratory environment.

The timeframe for conducting flight tests will depend on funding from Army programs of record and on existing munitions test schedules. Because of the ability to conduct testing concurrently with scheduled tests for other munitions, the cost of range time will be borne by PM transition partners. The contractor will be responsible for developing and integrating the components developed into test articles.

PHASE III: Incorporate a lethal payload on the micromunition. Other military uses of the technology might include soft-launch capability from aircraft or missiles. For the private sector, this technology could be adapted for search and rescue missions in mountainous areas, desert areas, over water, and for mining operations. The technology can also be useful in covering events such as special events for crowd control and for situational awareness.

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KEYWORDS: Hovering micromunition, hover, loiter, wind tunnel, GPS, video, propulsion, simulation

A12-010 TITLE: <u>Shape Changing Maneuverable Munition Using Novel Alloys/Materials for Flight</u>

Performance Enhancements

TECHNOLOGY AREAS: Materials/Processes, Weapons

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

OBJECTIVE: Design, develop and demonstrate novel alloys and materials for gun-launched transforming projectiles. These novel materials are intended to enhance the aerodynamic/flight characteristics of munitions to increase range and accuracy.

DESCRIPTION: The Army seeks to expand the missions and capabilities of its warfighters without developing new weapons systems. Legacy weapons systems (e.g., M256 120mm cannons, 40mm grenade launchers and 60mm mortar weapons) presently have "direct fire and forget" capabilities. The Army is looking to develop indirect fire/guided/smart munitions with the ability to correct course to a designated target.

Implementation of novel alloys/materials (e.g., shaped memory alloys) into developmental munitions can make them lighter, easier to manufacture, help provide more lethal payload by taking up less internal volume, improve strength and be less expensive while at the same time altering flight characteristics to improve accuracy and precision. The goal of this effort is to select a material that increases range by 30 percent range while maintaining or increasing accuracy.

Past efforts include the use of shape-changing alloys to alter the geometry of fins, nose cones, canards, and boat tails to increase range and precision.

PHASE I: Investigate and select candidate novel alloys and materials. Perform finite element analysis, laboratory/bench testing, and other computer simulations to predict material behavior under a high-G environment. Develop a model using the chosen material in preparation for a wind tunnel test that will be conducted in phase II. The model should reflect an existing projectile between 40 mm and 155 mm. The wind tunnel model will have the ability to change its shape by utilizing the novel alloy. Predict projectile aerodynamics and begin computational fluid dynamic (CFD) analysis to refine aerodynamics predictions. Deliver a detailed report characterizing the materials evaluated.

PHASE II: Conduct wind-tunnel tests using the model developed in phase I at various Mach numbers and angles of attack, and command the materials to deform by applying external stimuli. Analyze the aerodynamics data collected from the wind tunnel tests by using simulation studies to quantify the maneuverability of the airframe. Conduct laborotory bench-scale tests to evaluate material performance in operating temperatures between -25 F to 145 F. Conduct accelerated aging tests to demonstrate life cycle effects on the material from hysterisis, since permanent deformation will need to be avoided.

Fabricate at least 2 full-scale projectiles for a gun-launched flight test. The munition must survive gun launch and must be commanded to change shape during flight. Conduct a side-by-side test for range and accuracy with the conventional baseline projectile identified in phase I.

Design or specify tooling and manufacturing methods required to produce the projectiles at a cost comparable to that of existing projectiles.

PHASE III: The material could be incorporated in a wide range of currently munitions to enhance lethality, range, and accuracy. The success of this effort could translate into small arms improvements.

Shape changing materials have numerous non-military applications, particularly in the automotive, aviation, biomedical, and advanced computing fields.

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KEYWORDS: Shaped memory alloys, computational fluid dynamics, transforming munitions, expanded mission and capabilities.

A12-011 TITLE: Chlorinated High Energy Density Explosive Materials

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Develop new syntheses of chlorinated derivatives of cyclic nitramine explosives, including chlorinated RDX, and generate samples of the new materials for property tests.

DESCRIPTION: The Army recognizes a continuing need for more powerful high explosives that have improved energy density. N-nitro derivative materials such as the cyclic polynitramine explosives 1,3,5-triaza-1,3,5-trinitrocyclohexane (RDX) and 1,3,5,7-tetraaza-1,3,5,7-tetranitrocyclooctane (HMX) are high explosives widely used in military propellants and munitions. Functionalization of cyclic nitramines such as RDX, HMX and CL-20 is a major synthetic challenge, if successful will revolutionalize the energetic materials research. Improved materials with higher energy density and better stability to heat and during storage are highly desirable. To increase the energy of nitramine materials further, a highly promising strategy is to modify the inherent crystalline density of the materials by structural substitution of hydrogen atoms with chlorine atoms.

There are a variety of chlorination methods that may be applicable to replacing the hydrogen atoms of RDX with chlorine atoms, including radical, nucleophilic and electrophilic processes. From an eventual manufacturing point of view, using RDX as the starting material will facilitate production scale-up of new materials after process engineering is used to improve product yields. However, cyclic nitramine explosives are susceptible to degradation under certain conditions. For example, they are susceptible to decomposition to triazines upon alkaline hydrolysis, so these and other degradation pathways must be avoided or mitigated in the synthetic processes.

The new synthetic methods resulting from this project are likely to also be applicable to chlorination of other structurally related nitramine explosives of interest, including HMX and CL-20.

PHASE I: Identify new synthetic methods to chlorinate cyclic polynitramine high explosives in a controlled manner, from partial to full substitution. Spectroscopically characterize the resulting products and address potential synthetic pitfalls and alternative strategies. Demonstrate at least one safe and useful synthetic method for producing small quantities (As a part of energetic material development , first gram quantities of the materials are produces for initial sensitivity testing , compatibility and handling process optimization) of chlorinated derivatives of RDX. A safe method is one that is environmentally benign with non exothermic reaction conditions required for optimization and scale-up of these materials, while useful means producing the desired compound within a small number of reaction. Supply samples of chlorinated RDX derivatives for explosive performance testing at Army facilities including but not limited to combustion calorimetry, safety testing, Heat of formation, density measurement , Detonation velocity measurement, small scale gap tests are common thermo chemical methods used to evaluate new materials and compare with slandered bench mark explosives such as RDX, HMX and CL-20. Evaluate the performance of the new derivatives, and select the best performing candidate(s) to move forward into Phase II and later development.

PHASE II: Perform laboratory scale-up of the synthesis and purification of the best chlorinated explosive materials identified in Phase I up to pound levels. Conduct process engineering to improve final isolated yields. Prepare larger quantities of derivatives for advanced testing in Army facilities. Testing such as gurney energy, dent/rate, detonation velocity, etc.

PHASE III: The materials developed under this effort will have dual applications for military and commercial applications. The new explosive materials may have particular applications for commercial mining operations and in demolition applications.

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KEYWORDS: Explosive, chlorination, RDX, HMX, cyclic, nitramine

A12-012 TITLE: <u>Energetic Modification of Aluminum Nanoparticles</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Develop methods to improve the energetic properties of aluminum nanoparticles for increased energy density and reaction rates compared to conventional aluminum nanoparticles.

DESCRIPTION: Energetic materials require a fuel and an oxidizer. For example, in black powder, the fuel (sulfur and carbon) and oxidizer (potassium nitrate) exist as separate, discreet particles that have to overcome mass transport limitations in order to react and release energy. In contrast, in TNT, RDX, CL-20 and other high explosives, the fuel and the oxidizer are both part of a single molecule. As a result, these monomolecular materials exhibit extremely high reaction rates due to the proximity of the fuel and oxidizer. Unfortunately, molecular explosives have energy densities that are lower than those possible with composite materials. Composite materials have higher energy densities, but low explosive power due to slow reaction rates caused by poor mass transport between the large, separate, grains of fuel and oxidizer. One potential way to improve the performance of composite energetics is to use composites made from energetic nanoparticles. In these materials, finely dispersed nanoparticle fuel/oxidizer mixtures greatly reduce mass transport distances (from microns for conventional materials to 10 nm or less in nanoenergetics), and as a result, nanocomposite energetic materials have the potential to both increase the energy density of the explosive while producing energy release rates approaching those of molecular explosives.

The fuel of choice for these nanoenergetic materials has generally been aluminum nanoparticles, typically and preferably with an average particle size of 80 nm. Metallic aluminum is a common energetic fuel in many traditional and nano-energetic material applications, including pyrotechnics, propellants, and thermobaric explosives, and as a result, the preparation of aluminum nanoparticles has become a mature technology. Aluminum nanoparticles are commercially available in a variety of sizes ranging from 10–100 nm in diameter. Aluminum is a very electropositive metal, and the reason that it can be handled in air is that a thin, tightly adhering, coating of alumina (Al2O3) forms on the surface that passivates the metal. The thickness of the Al2O3 layer is relatively constant for different particle sizes, which means that in the case of aluminum nanoparticles, the passivating Al2O3 layer represents a significant fraction of the particles, which in turn, greatly decreases their reactivity.

Since the presence of the unreactive Al2O3 passivation layer is unavoidable, this solicitation seeks proposals to develop ways to modify this layer to make the aluminum nanoparticles more reactive. Specifically, chemical modification of the Al2O3 layer with energetic compounds should be possible without diminishing or changing the amount or activity of the elemental aluminum at the core of the particles.

PHASE I: The synthesis and investigation of chemically modified aluminum nanoparticles will be undertaken to increase their reaction rates for use in explosive applications. Formulations consisting of the modified aluminum with oxidizers such as bismuth oxide and copper oxide will be fabricated. Physical and chemical characterization of these materials will be performed. This will include basic sensitivity tests (according to MIL-STD 1751A Methods 1015, 1024, and 1032 or equivalent) , aging tests and x-ray fluorescence to determine the extent of the surface modification. Preliminary burn rate and other kinetic measurements will be made and compared to more "standard" nanothermite materials consisting of unmodified nanoaluminum and various oxidizers. The overall technology process for synthesizing modified aluminum nanoparticles will be evaluated against the standard in order to determine feasibility and extent of energetic properties improvement.

PHASE II: The synthesis of modified aluminum nanoparticles will be scaled up to produce approximately 10 kg of material for further evaluation. A detailed cost analysis and management plan, including risk analysis & mitigation methods for producing and operating a pilot scale production plant,should be generated as well. The efficacy of the design will be demonstrated by showing data from appropriate experiments, such as were described in Phase I. Testing in a sub-scale version of an appropriate end-item will be conducted to demonstrate the feasibility, from both a performance and cost perspective, of using modified nanoaluminum-based energetic composites in explosive formulations. Data from experiments at the laboratory scale will be analyzed. The performance of the modified aluminum nanoparticles as an explosive or explosive additive will be compared with conventional explosives.

PHASE III: The optimized energetic nanoaluminum composite will be incorporated into real munitions and the functionality of the whole system will be tested. The performance of the nanoaluminum composite will be evaluated for future applications. The new materials and technology developed under this effort are anticipated to have use in a wide variety of civilian applications beyond defense fields. The commercial potential for dual-use applications will be evaluated in this phase through strategic partnerships.

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KEYWORDS: Aluminum, energetic, nanoparticles, composite, energy density

A12-013 TITLE: Novel Rifle Sight Overlay

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Weapons

OBJECTIVE: Design, develop, prototype, and demonstrate a low-cost, SWaP (Size Weight and Power) optimized, high-resolution, dynamic electronic overlay display system for small arms sights that provides improved performance over current commercially available systems.

DESCRIPTION: This topic will address challenges soldiers face acquiring targets, ranging, calculating, applying a ballistic solution, and engaging multiple targets at the weapon's effective range limit. The fielding of increasingly sophisticated sights and fire control systems for small arms is creating a need for a new generation of scopes with the ability to optically overlay, in the weapon's sight, information like range to target, heading to target, an adjusted reticle, etc. Dynamic optical overlays have been used for Heads-Up Displays (HUDs) in aviation and in other applications, but this technology has not yet been successfully implemented in advanced, low-cost optics for small arms.

Having a scope that overlays dynamic information to the weapon's sight will provide the user improved performance through a high rate of target identification, increased probability of hit, and improved lethality. A successful solution will overcome current miniature displays, such as poor operation at cold temperatures (refer to MIL-STD-810) and poor visibility in bright sunlight.

The main purpose of this topic is to identify innovative ideas and technologies for miniature display systems that will allow the development of a new family of rifle scopes equipped with a high resolution (ideally 1240x1080 or greater) electronic graphic overlay display capability, while using existing commercial signal interface standards and not imposing significant cost increases to the sighting systems, which currently cost between $400-$1000 on average. The overlay should not significantly reduce reliability (e.g. mean-time between failure, battery lifetime) of the optics system. The proposed system must be designed so that production articles will survive the high shock loads associated with small arms fire and the harsh environmental conditions to which military systems may be subjected (MIL-STD-810). At the same time, a successful solution must account for the size, weight, and power requirements of today's soldier.

PHASE I: Develop a detailed design of proposed electronic graphic overlay technology. Perform a tradeoff study of candidate configurations/options and identify the best solution in terms of SWaP and optical performance. The final report shall be a complete design (software and hardware) of the proposed module. The report shall also provide an estimate of the display's cost, size, weight, and power consumption.

PHASE II: Based on the selected Phase I design, build a prototype of the proposed electronic graphic overlay module. Integrate it into an individual soldier weapon-mounted direct-view optical scope. Perform side-by-side operational tests with the traditional military optic that most closely resembles the prototype system. Demonstrate target identification, probability of hit, and lethality. Demonstrate the compatibility of the system with existing ancillary fire control systems. Conduct this demonstration with members of the customer community. Submit a report detailing test and demonstration results. In this report, identify how the overlay impacts key performance parameters, e.g., probability of hit, relative to the military optic used in the demonstration.

PHASE III: In conjunction with PM-IW, optimize the prototype fabricated in Phase II to commercialize the system. The technology developed under this effort should result in a technology suitable for integration into a new family of optical scopes equipped with electronic graphic overlay displays. The development of this technology for sighting systems has considerable commercialization potential. Some commercial applications for this technology include commercially available rifle scopes, automobile and aircraft head-up displays, video game technology, scuba and underwater applications, and digital camera technology.

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KEYWORDS: SWaP, fire control systems, overlay display module, small arms sights, optics, display

A12-014 TITLE: Novel Gun Barrel Rifling Technology

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

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

OBJECTIVE: To develop and demonstrate a novel gun barrel rifling technology that overcomes the current limitations of mechanical broaching and electrochemical machining. This technology would enable the rifling of new erosion resistant gun barrels and liners made from materials such as ceramics and refractory metals.

DESCRIPTION: The focus of this research is to develop and demonstrate a novel rifling technology that overcomes the current limitations of mechanical broaching and electrochemical machining and is more economically feasible. The difficulty in rifling the bore is a significant impediment to the implementation of advanced liner materials. A new method of rifling is sought that can machine both refractory metals and ceramic liner materials. New erosion resistant material materials for barrels include refractory metals such as Tantalum-Tungsten Alloys and Ceramics, such as SiN, which are very difficult to broach mechanically or to machine by electrochemical means. The new process should be cable of application in bores as small as 25 mm, as well as larger caliber weapons, such as the 120 and 155mm cannons.

Required Phase I deliverables will include the production of two grooved planar samples 6 inches long in a tantalum liner material and two grooved planar samples 6 inches long in a SiN ceramic material. The rifling grooves should be approximately 0.15 inch wide by 0.020 inch deep. The tolerance shall be +/- 0.005 inch. In addition, there is a requirement to produce a straight groove in a 2.5 inch diameter 4340 steel tube (HRC 40) that is 6 inches long. Material removal rates should be at least 0.1 in^3/min.

PHASE I: The primary objectives of the Phase I effort are to demonstrate a laboratory scale novel rifling system for refractory materials and ceramics that can be scaled up for production and to produce a set of samples for evaluation. The proposed method is required to be more economically feasible than mechanical broaching and electrochemical machining, as substantiated by a cost analysis. The laboratory scale demonstration must produce two grooved planar samples 6 inches long in a tantalum liner material and two grooved planar samples 6 inches long in a SiN ceramic material. The rifling grooves should be approximately 0.15 inch wide by 0.020 inch deep. The tolerance shall be +/- 0.005 inch. In addition, there is a requirement to produce a straight groove in a 2.5 inch diameter 4340 steel tube (HRC 40) that is 6 inches long. The samples will be evaluated by ARL to determine process suitability for further funding. The contractor's readiness for Phase II will be judged by the ability of the proposer to adequately address the necessary design and hardware/software features, safety issues and process parameters required to produce a system for full scale gun barrels.

PHASE II: Building on the successful results of Phase I, the primary goal of the Phase II effort will be to demonstrate a full scale rifling system by producing a full length gun barrel and to perform a cost analysis assessment for future production to expand the technology to enable the development of a robust production system capable of meeting current and future Army needs.

Reasonable performance related goals expected to be achieved by the proposer related to the execution of this project are the demonstration of a 78” long spiraling rifling barrel similar to that required for the Bushmaster 242 in steel (HRC 40) by the end of year 1 and in a tantalum alloy by the end of year 2. The rifling grooves should be approximately 0.15 inch wide by 0.020 inch deep. The tolerance shall be +/- 0.005 inch. The rifled pattern shall be (1) rotation for every (6) diameters and result in the formation of 18 grooves and 18 lands.

PHASE III: DUAL USE APPLICATIONS: The development of this technology will allow for the use of new machining techniques that could be applied to a wide variety of grooving applications such as separation plates in proton exchange membrane fuel cells, channel wall combustors for rocket nozzles and scramjets, heat exchanger panels for high efficiency cooling on aircraft and coal gasification plants.

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KEYWORDS: Rifling, waterjet, grooving, milling, broaching, refractory metal, ceramic liner

A12-015 TITLE: Miniature Infrared Hyperspectral Imager

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Sensors

OBJECTIVE: To develop a miniature MEMS technology based infrared hyperspectral imager operating at a fast speed to detect IEDs and other chemical/biological agents.

DESCRIPTION: There is a need for a miniaturized, portable, hyperspectral imaging camera that can be used by the war fighter or Unmanned Ground Vehicle (UGV) or Unmanned Arial Vehicle (UAV) operator to detect threats and take the necessary actions to mitigate the potential dangers. Improvised Explosive Device (IED) detection remains the most difficult task of immediate importance. The IED may be loaded with chemical/biological agents. It is critically important to identify and disarm these IEDs before they explode. In the event of a detonated IED, it is important for the war fighter to access the area of the explosion for dangerous chemicals or biological agents before entering. A mobile hyperspectral imaging system can analyze the spectral signatures in the plume real time prior to the war fighter or first responder entering the explosion site, thereby lowering the health risk associated with these threats.

Hyperspectral sensors collect hundreds of bands by scanning in either the spatial or spectral dimension. Most applications for the war fighter do not need all the spectral information acquired by hyperspectral sensor but require accurate images in a select number of spectral bands. In addition there are applications where the ability to collect both spatial and spectral data simultaneously is critical to the success of the mission. Some examples are: a sensor on a moving platform, a moving target, a dynamic scene that is changing rapidly. The ability to correlate spatial, spectral and temporal data using a miniature hyperspectral camera will enable higher signal to noise, higher probability of detection and lower false alarms.

Recent developments in MEMS (Micro Electro Mechanical System) technology provide opportunity to develop low-cost, miniature hyperspectral imagers that can be used on UGV and UAV platforms as well as on rifle sights. The war fighter has numerous applications for a spectral imaging camera, such as IED detection, chemical/biological weapons detection, missile warning, missile seekers, mine detection, kill assessment and surveillance and reconnaissance.

PHASE I: Develop a conceptual design of an optical MEMS technology based hyperspectral imaging system operating in the infrared using a Fabry-Perot filter that may be actuated electrostatically for wavelength tuning. Discuss in detail selection of selected spectral region useful for IED and/or chemical and biological agent sensing. Carry out theoretical device modeling and design for MEMS based Fabry-Perot filters with wavelength tuning capability in the selected spectral region with sufficient spectral resolution and spectral range needed to carry out spectral imaging. Perform necessary experiments to demonstrate operational and tuning capability of MEMS based filters. Discuss in detail the manufacturing process for the tunable filter. Demonstrate the feasibility of developing a hyperspectral imaging system in the selected spectral region by taking into account size, weight, speed, power requirements as well as human or machine interface issues and cost in selecting optics, commercial camera and image acquisition and processing tools. Deliver a report including justification for selection of the spectral region; the tunable filter design, modeling, manufacturing process and characterization results; and detailed hyperspectral imager design.

PHASE II: Fabricate and characterize MEMS based Fabry-Perot filters in the selected spectral region which incorporate electrical actuation and sensing elements and demonstrate wavelength tuning operation. Address various fabrication issues such as electrical interfaces, device size, speed, quality, and robust operation. Design and build a prototype hyperspectral imaging system by integrating the MEMS based filter, electrical interface and optics with a commercial camera by integrating them together with automated image capture and spectral analysis tools. Demonstrate performance of the hyperspectral imager with laboratory and field data collection. Deliver a final report and a prototype hyperspectral imaging system.

PHASE III: Further research and development during phase III will be directed toward refining the final prototype hyperspectral imager design incorporating design modifications based on results from test conducted during Phase II and improving engineering/form-factors, equipment hardening and manufacturability designs to meet U.S. Army CONOPS and end-user requirements.

Dual Use Applications: There are numerous applications for low-cost miniature hyperspectral imagers that can be produced using MEMS technology.
Military application: The hyperspectral imaging camera can be used for application such as IED detection, chemical/biological weapons detection, missile warning, missile seekers, mine detection, kill assessment and surveillance and reconnaissance.
Commercial application: gas leak imaging in oil, gas and chemical plants; greenhouse gas monitoring; emission monitoring for regulatory compliance; remote sensing for process control in boilers; food inspection; agriculture; homeland security and medical research and diagnostics.

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KEYWORDS: IED, chemical/biological, infrared, detection, hyperspectral, imaging, camera, MEMS, miniature

A12-016 TITLE: High Efficiency Generator Set with Integrated Energy Recovery

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop an internal combustion engine (ICE) design that integrates thermal electric (TE) and/or pyroelectric (PE) components as part of the ICE configuration for a JP-8 powered generator set[1,5,6] (genset). This innovative design will result in a potential increase of ICE efficiency by additional 5~10% from the current ICE efficiency range of 25~35%. The design process should optimize engine configuration and operating parameters.

DESCRIPTION: To meet the ever increasing energy demand in the theater of operations, one strategy is to invest in existing technology for improvement, such as increase of energy conversion efficiency of machinery and devices. Since a large portion of energy needs in battlefield is generated by gensets running JP-8 fuel in the ICE, the improvement to the efficiency of the generator set will have a significant impact on both operations and logistics. For a current genset at 100 kW power level, only about one third of the energy in JP-8 is converted to electricity[1] under optimal operation conditions, and the rest of the two thirds are wasted in the form of engine heat. The 2/3 of wasted heat for this 100 kW genset can be potentially converted to an additional 10-20 kW of electrical power.
This topic intends to explore the potentials of using part of the engine heat to generate additional electricity through integration of thermal electric [2-5] and/or pyroelectric [4] materials in engine configuration of the genset. The innovative concept, novel approach, and new methodology are highly encouraged to embed thermal electrics and pyroelectics into the engine itself. The innovative research lies in answering basic questions of what engine configuration modifications, if any, to be made; and how to optimize engine performance with new configuration under full and half load modes. Any new type of thermal electric and/or pyroelectric materials with promising potentials may be considered as candidates for this effort. Ultimately, this design could provide generalized concepts for engine designs of future.

PHASE I: Demonstrate innovative concept in engineering considerations for engine design with integration of TE and/or PE. Perform a study to compare conventional design that has neither TE nor PE to the new design in details. The key concepts of the study are selection and most optimal placement of TE and/or PE materials with the ICE. The heat transfer from source to devices and from the devices to the environment is particularly important. Computer simulations and/or experimental demonstrations are highly required. During this phase commercialization aspects must be considered and potential plans for commercialization elucidated.

Upon completion of this phase the following criteria is expected to be met:

1. Demonstrate by experimentation or simulation
(a) the concept and performance of target TE and PE devices
(b) the ICE integration methodology and thermal coupling of TE and PE devices

2. Select placement, geometry and size optimization of TE and PE devices within the ICE

3. The results will be documented monthly in technical progress reports

PHASE II: Construct and demonstrate a prototype of JP-8 fueled electricity generator with integrated thermal electric and/or pyroelectric configuration. Perform evaluation and testing to demonstrate an overall fuel efficiency increase by additional 5~10%.
Upon completion of this phase the following criteria is expected to be met:

1. Demonstrate experimentally by several undertaking the performance of TE and PE devices when embedded in an ICE section. This will allow to study and demonstrate experimentally particular design idea before building a working ICE. Major aspects to be considered
(a) Methodology of embedding
(b) Thermal coupling
(c) Efficiency of heat exchange

2. Demonstrate performance of embedded TE and PE devices in an actual ICE

3. Develop realistic commercialization plan

4. The results will be documented in quarterly technical progress reports

5. Deliver one complete system to the Army before the end of the contract

PHASE III: Successful development of improved high energy efficiency JP-8 genset with integrated thermal electrics and/or pyroelectric will not only benefit the Army with savings in fuel and life, but also benefit commercial energy industry with new market for internal combustion engine related applications. New engine design concepts may be generated as the result of this effort.

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KEYWORDS: internal combustion engine, generator set, thermal electric, pyroelectric, JP-8, fuel efficiency, design, energy

A12-017 TITLE: Tunable Stiffness Thorax/Mechanism for Flapping Wing MAV

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Investigate techniques for achieving flapping wing action in a miniature air vehicle on the order of <5 grams and <4" cube with a flapping rate of 5-100Hz. Flapping mechanism should have easily tunable and measurable stiffness properties.

DESCRIPTION: One of the biggest problems with small flapping wing air vehicles is that energy density of batteries is highly limited. Therefore, the flapping mechanism must be efficient and lightweight. By using elastic energy storage in the flapping mechanism, the efficiency can be improved. The ability to tune the stiffness of such a mechanism will allow for a variety of wings and actuators to be rapidly tested to determine their performance properties.

It is envisioned that the tunable flapping mechanism would be focused on helping to conduct research activities at this early stage in development and preliminary research. Sacrifices in weight and size are acceptable in favor of improved functionality. Basically, the purpose of this mechanism is to aid researchers in matching flapping mechanism properties to wing and actuator properties. Then, to build a flying prototype, a non-adjustable super-lightweight version of the flapping mechanism would be constructed such that it matches the experimentally optimized properties of the adjustable mechanism.

Eventually, it is planned that a model of the tunable flapping mechanism could be constructed. This model could then be coupled to models of a variety of wings and actuators. Overall, these tools would speed the development of improved flapping wing micro air vehicle prototypes. Therefore, it is important to be able to measure the properties of the flapping mechanism, including stiffness, masses, damping, and friction properties.

This flapping mechanism does not necessarily need to depend on a specific source of actuation. Actuators could be incorporated into the mechanism in a variety of different ways. Currently, some research is underway for using macro fiber composites and piezoelectric bending actuators as a technique for driving the flapping wings, however systems of electric motors and gears could also be an option, as well as a variety of other techniques like shape memory alloys. The flapping mechanism should strive to focus more on the stiffness adjustability aspect rather than the source of input motion, if possible.

The mechanism ideally will be able to achieve the maximum possible range of motion, thus providing improved flight properties in the micro air vehicle due to increased thrust production.

To summarize, we are looking for an investigation into various possible techniques for achieving a variable stiffness flapping mechanism to be used on a micro air vehicle.

PHASE I: The Phase I requirement would be to develop approaches for achieving variable stiffness in a flapping mechanism tailored to micro air vehicles. The technical feasibility of these approaches must be investigated to determine if a particular approach emerges as the most likely to provide successful future developments. Modeling and simulation in support of this goal would be useful in making a case. Also, experimental data should be collected to explain the results of the feasibility study.

PHASE II: The Phase II expectation would be to develop a number of functional prototypes allowing for stiffness to be adjusted over a range large enough to optimize the function of current micro air vehicle flapping mechanisms. Each prototype should offer unique features such as varied range of adjustment, or alternative approaches to adjustment, such that a large scope of potential vehicles could be developed using this technology. The prototypes should have fine resolution and consistent repeatability to allow researchers to conduct sensitivity analyses of small variations in the system. The prototypes should have some kind of built in method of determining stiffness properties and mass properties, such that future models can be developed.

PHASE III: The end-state of this research should be lightweight flapping wing micro air vehicles that have been tuned to have optimal efficiency. Finalized lightweight mechanisms would be derived from research conducted using the tunable flapping mechanism as a development tool. The tunable mechanism could be used by a variety of research groups and consumers in development of new air vehicles with improved performance properties. Some consumers could include the hobby industry, or possibly biologists seeking a greater understanding of insect flight dynamics.

An additional possible application could be the development of dynamically tunable flapping mechanisms, where a small actuator is able to tune the stiffness of the mechanism in response to a variety of stimuli including command inputs or sensor/controller inputs. Such a development could improve the suitability of a particular vehicle to a wider range of environmental conditions.

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KEYWORDS: micro, unmanned, aerial, air, vehicle, mav, uav, flapping, wing

A12-018 TITLE: Fabrication of functionally graded fine grained magnesium alloys for structural applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

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

OBJECTIVE: Develop and demonstrate a manufacturing methodology for advanced fine grained magnesium (Mg) alloys to achieve both increased strength and ductility for potential armor and structural applications. A manufacturing technique that goes beyond flat plates and allows geometrical and compositional control would be an added benefit.

DESCRIPTION: Advanced lightweight magnesium alloys have shown significant promise to reduce the weight of structural and ballistic armor components. Specifically, lightweight ultrafine grained (UFG) alloys have shown tremendous increases in strength and ductility over conventional coarse grained, conventionally processed materials, but are produced and examined only at laboratory size scales. Current fabrication methods, such as Equal Channel Angular Extrusion (ECAE) and cryomilling, limit both the size and complexity of shape that can be produced with UFG materials. These methods typically require further processing to consolidate or integrate the UFG material components into practical structures. This final processing often leads to degradation of the benefits associated with

UFG characteristics. Finally, it is envisioned that there is potential to produce advanced functionally-graded structures if the geometry and composition of the fine grained materials can be more closely controlled. This could include increased strength at one surface/feature and increased ductility at a different surface/feature. While the addition of rare-earth (RE) elements to Mg alloys has offered a route to higher strengths by precipitation hardening, these additions can be expensive for high-volume applications. It is expected that the proposed manufacturing process will offer improvements to the mechanical properties to multiple classes (both with and without RE elements) of Mg alloys by better control of the processing.

What is needed is a method to fabricate large-scale, complex structures using fine grain alloys. The process developed should enable the production of complex geometries, suitable for direct integration with existing vehicle armor systems. The process should also allow for functional grading of the structure by controlling both the geometry and composition of the alloy. The development of functionally graded material will enable utilization in a broad range of applications currently not feasible for Mg. For example, a ceramic surface layer could result in lightweight materials suitable for wear resistance applications (such as brakes) or a well-adhered surface coating could promote enhanced corrosion resistance.

PHASE I: Identify and develop equipment and processing methodologies to demonstrate magnesium based samples with the following criteria: specific density less than 2 g/cc, average grain size less than 5 micrometers with random grain orientation, ultimate tensile strength greater than 450 MPa and relative tensile ductility elongation greater than 8%. Successful completion of Phase I would include a deliverable of a plate with above properties of at least dimensions 600mm x 600mm x 25mm. In addition, a curved demonstration piece (approximately 150mm x 150mm) shall also be produced. A report detailing cost analysis and feasibility study to produce a plate with minimum dimensions 1200mm x 2400mm x 38mm is also required. The report should also provide a plan for producing 75mm square functionally graded plates with (a) a ceramic surface layer and (b) metallic or intermetallic surface layer. Three different surface layer thicknesses will be required.

PHASE II: Produce a series of at least 6 prototype test plates, suitable for ballistic testing. Plates shall maintain the minimum mechanical and physical properties from Phase I, with a minimum plate size of 1200mm x 2400mm x 38mm. All functionally graded plates discussed in the Phase I report shall be produced and evaluated. A demonstration piece of a geometry larger and with more complex curvature than in Phase I will be fabricated.

PHASE III: The production of high strength sheet and plate product could see an abundance of applications in both military and civilian realms. The probable military applications span from lightweight personnel protection to large ground vehicle structure/armor components. High-strength, lightweight sheet product would find its way into the civilian market as preforms for sheet-formed items or perhaps vehicle body panels. The transition to operational capability in order to achieve these prospective applications will be based on a transition from the Phase I research and development to achieve property goals to the scale-up demonstration in Phase II, and then commercial production in Phase III.

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KEYWORDS: magnesium alloys, ultrafine grain, functionally graded, high strength, lightweight alloys, manufacturing scalability

A12-019 TITLE: Real Time Structural Health Monitoring of High Velocity Impact Events

TECHNOLOGY AREAS: Materials/Processes, Weapons

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

OBJECTIVE: Develop an in situ monitoring method that provides:_ (1) Real time in-the-field stress measurements under blast loading conditions, (2) durable to pressure wave sensors adaptable to complex geometry, (3) provides measurement of time dependent elastic-plastic transition on the surface of the structure, and (3) gives experimental validation of 3D FEM and material deformation models.

DESCRIPTION: Impovised explosive devices (IEDs) produce significant structural damage to inaccessible regions of transport vehicles that remain in operation, and thereby leave the warfighter susceptible to vehicle malfunction. These high velocity impact events generate extreme strain levels and nonlinear, complex waves propagating through the structure. An effort is underway to understand the penetration mechanisms real time to better calibrate analytical models.

PHASE I: Develop sensors and feasible structural apparatus that survive the blast loading effect and provide ability to measure emerging wave field. Develop signal analysis algorithms to determine exact impact location and elastic-plastic states within the structure.

There exists several criteria for the in situ sensors and associated innovative systems to prove successful: (1) must be compatible with both metallic and composite systems that exhibit highly anisotropic material properties, (2) adaptable to platforms with variations in thickness (up to 3 cm) and radius of curvature, (3) able to withstand repeated loadings of projectile velocities on the order of 1-10 km/s, and (4) have built-in self-powering or very light weight power source, such as harvesting energy from mechanical energy from the inherent movement of the vehicle.

PHASE II: Test methodology and sensor apparatus to low (500 m/s) and high velocity regime (1-10 km/s) and demonstrate analysis algorithms, which can provide exact source location and recover stress states within the structure. The minimum following deliverables are expected: (1) at least 3 in situ sensor prototypes that improve successful design from the low velocity to the higher velocity regime test cycles for metallic and composite platforms, (2) demonstrate very light weight power sourcing, and (3) demonstrate resolution accuracy within 2-3 mm.

PHASE III: Transition to military platforms for retrofitting such design that is lightweight and relatively inexpensive. Similar designs should be achievable for foreign object damage to commercial airframes.

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KEYWORDS: blast loads, embedded sensors, real time structural health monitoring, impact loading, damage detection, stress analysis

A12-020 TITLE: Wings and Propulsion for MAV Gust Rejection

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop bio-inspired or other lift and propulsion designs that are optimal for small and very small scale flight gust rejection. Exploit some of the same mechanisms that bio-systems use to fly in turbulence to design better wing and propulsion systems for micro air vehicles.

DESCRIPTION: Background: Several effects conspire to make conventional aircraft designs problematic for micro and nano scale aerial vehicles. In particular, the low Reynold's numbers (Re) encountered for such systems lead to thick boundary layers which tend to produce large amounts of parasitic drag, tip vortices are likely to produce large rolling moments, and the very small moment of inertia of such small systems makes them very prone all modes of tumbling. Conventional designs, such as the quad rotor, find that drag forces increase very rapidly as scales become smaller.

The combination of large unsteady flows over the wings and small moment of inertia makes these small aircraft particularly vulnerable to gusts and other disturbances of the air. Flight in crowded urban or other cluttered domains requires precise and rapid movements in response to the changing atmosphere. Studies of biological systems suggest that they have several stratagems for coping with such gusts, including sensing, wing shape modulation, and tailoring of propulsion to the Re regime in which they find themselves. Nonetheless, biological systems solve these problems over a mass range of six or so orders of magnitude, which is ample evidence that they can be solved.

PHASE I: Develop a concept for researching and exploiting the types of lift and propulsion principles used by biological systems for agile flight in gusts and turbulence. Outline how these principles could be applied to the design of very small unmanned aerial vehicles. This concept development should identify and evaluate the evidence for various approaches. In particular it should consider the following:
Mechanical aircraft depend on fixed or rotating wings for lift, and usually, also for propulsion. By contrast, birds and insects use reciprocating (flapping) wings for lift and propulsion. As aircraft are designed to enter the Re regime of these natural, is has become clear that conventional rotating and fixed wing designs face severe handicaps at these low Re. The thicker boundary layer at low Re results in more drag and more energy in unstable flows which can produce torques. Are we forced therefore to adopt the reciprocating wing design of birds and insects, or are there other paths to MAV navigation and gust rejection that retain the advantages of circular motion? This is an example of the type of question that must be answered to pick optimal designs for MAV navigation and gust rejection.

PHASE II: Elucidate the theoretical basis of the gust rejection mechanisms used by the fliers of the animal kingdom. Design, build, and test a prototype very small unmanned aerial vehicle which incorporates some or all of the gust rejection techniques.

Deliver a comprehensive report on the lessons learned and a copy of the prototype.

PHASE III: Manufacture and sell gust rejecting micro air vehicles capable of operating in gusty and turbulent urban environments.

Such vehicles would be extremely useful for military surveillance and reconnaissance operations, where there ability to maneuver near the ground and into tight spaces would make them both extremely capable and stealthy.

There would also be extensive civilian applications, including police and border patrol, search and rescue in difficult terrain, building and area security, and inspection of hard to reach areas.

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KEYWORDS: micro air vehicle, gust rejection, wing, propulsion

A12-021 TITLE: Optimizing the use of atmospheric energy to extend range and endurance of low altitude UAVs and small manned aircraft

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a technology/algorithm package to provide autonomous in-flight guidance and or control of the flight path of Unmanned Aerial Vehicles (or small manned aircraft) to take advantage of self acquired knowledge of the energetics of the atmosphere along or adjacent to the flight path. Such a capability is sought to reduce dependence on preflight assumptions of flight conditions to be avoided as well as those that could be used to the mission's advantage. A technology and associated software that provide such knowledge over ranges of a few kilometers or several minutes of flight time will be considered responsive to this solicitation.

DESCRIPTION: Small aerial platforms operating within the lowest few kilometers of the atmosphere are particularly susceptible to atmospheric turbulence, shear and precipitation. Mission endurance or even mission accomplishment can be compromised by encountering unexpected flight conditions. With platforms designed to provide increasingly long times aloft, the reliability of pre-flight weather forecasts diminishes placing more emphasis on in flight decision making that avoids or utilizes atmospheric phenomena that are encountered. This ability to detect, navigate to and utilize sources of atmospheric energy autonomously is most desirable for missions where communications between mission control and the platform may be compromised or withheld for tactical reasons.

The goal is to enable an unmanned aircraft to "see" around its position, detect nearby sources of atmospheric energy, and continually direct the aircraft to the optimum flight position. This will allow the aircraft to avoid undesirable situations or to gain altitude, extend its range and hold station for long periods of time without using its fuel consuming engine, or to go silent for long periods of recon or conops.

The capability envisioned would be compact, lightweight and consume as little power as would make the approach useable by small aircraft. The technology would be generally platform independent and thus be usable on both manned and unmanned platforms. The flight management algorithms, however, would be designed to consider individual platform performance metrics to achieve optimal atmospheric feature avoidance or utility.

PHASE I: Assess in detail the feasibility of developing an autonomous in-flight flight control (advisory) system related to atmospheric features representing both advantages or impediments to mission accomplishment. Both the technology and the implementation of the flight control algorithms must be shown to be achievable within a few years. The implementation constraints mentioned in the description above must be met. A work plan for Phase II must be provided along with anticipated activity under a Phase III effort.

PHASE II: During this Phase, the technology must be defined in detail and a research version should be physically available for use in testing the key algorithms and flight control software in either a flight simulation or actual flight demonstration. It is expected that a reasonable fraction of the Phase II effort will be done through simulation to identify the more challenging atmospheric situations that would need to be investigated using actual platforms. While it may not be necessary to conduct real aircraft demonstrations within the Phase II resources, responders should provide detailed test plans and flight scenarios that could be used during Phase III.

The emphasis in Phase II will be on the atmospheric feature detection and flight control algorithms. The choice of technology should strongly consider the immediate availability of systems that can serve to demonstrate the utility of the technological approach and, in particular, the information management and flight control logic. It is further expected that the Phase II effort will identify modifications and improvements to existing technology required to meet the multiple platform accommodation requirements. Defining the platform host requirements (weight, power and volume) will be critical to judging applicability to specific aircraft.

The TRL for both the technology and algorithms will be determined upon completion of Phase II and will be used to define Phase III activities.

The market for the product of the Phase II effort must be reassessed and a plan for its manufacturing and marketing will become the basis for Phase III activity.

PHASE III: Begin marketing the capability developed during Phase II. It is expected that both a military and a civilian market will be identified. In addition to the obvious military applications, such an autonomous flight optimization package would most likely be of interest to the glider, lighter than air and small private aircraft communities.

REFERENCES: None

KEYWORDS: Autonomous; flight route planning; atmospheric energy; mission duration; platform survival; airborne remote sensing

A12-022 TITLE: Surface Engineering Technologies for Improved Gear Efficiency

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop surface engineering techniques capable of improving the power transmission efficiency of geared systems, to include thin gear coatings, surface finishing and texturing methods, and other methods to alter surface topology and/or chemistry. Candidate surface engineering methods should be appplicable to rolling and sliding contacts typical of tribological contacts in military vehicle powerplant and drivetrain components to include: gears, bearings, seals, piston rings, etc.

Demonstrate realizable efficiency improvements that can reduce vehicle fuel consumption. Reduction of component losses by an average of at least 20% should be achievable (95% efficient gear mesh should be improved to at least 96% with surface engineering). These technologies should be readily incorporated into existing designs for powertrain gearing to enable rapid introduction into existing military platforms.

DESCRIPTION: It is generally accepted that various methods of surface engineering can have large impacts on the power transmission efficiency of gearing. However, ground vehicles (both military and commercial) are subject to more stringent cost constraints than air vehicles such as helicopters. As a result, surface processing techniques are often not undertaken to optimize fuel efficiency, although these processes are becoming more common in recent years.

Decreases in surface roughness can lower friction losses in gearing, particularly where significant relative sliding occurs. Surface interaction is reduced, allowing a thicker lubricant film to form and potentially improving performance under loss of lubrication conditions due to the reduced heat generation and improved surface separation. Some processes exist to improve the surface roughness of machined surface to mirror-like finish, but it is critical that these processes also remove a minimal amount of material and do so uniformly to retain surface topography. Techniques for improving surface roughness beyond 2-4 microinch 'Ra' are sought under this topic.

Thin tribological coatings can also be used to achieve lower losses in these components. However, often these coatings do not achieve sufficient durability under high contact stresses typical of drivetrain components. If a coating is proposed, it must fail in a benign manner which does not adversely impact the ability of the gears or components to continue operation and deliver power. Coatings must be compatible with typical military vehicle lubricants, and must not expose the gear to environmental conditions that would adversely impact the hardness of the steel substrate. Triboligcal coatings are also sought under this topic, as well as additional techniques that have the ability to change the surface topography and/or chemistry to reduce frictional losses.

Proposals should describe candidate technologies for improving the efficiency of meshing gears through modification of the gear surfaces. Candidate technologies must be compatible with conventional gear and bearing designs, materials, and operating conditions. The most promising techniques will reduce friction, maintain or extend part life as compared to the baseline, add or remove a very small amount of material uniformly, add little additional cost, and not adversely impact material properties of the underlying steel (particularly hardness).

PHASE I: Investigate the application of surface engineering techniques to military vehicle driveline components in order to achieve lower frictional losses and improved power transfer efficiency. Tailor the surface engineering technology to powertrain components and establish validation metodology for comparing efficiency to baselines.

The Phase I should be able to quantify expected improvements in mechanical component frictional losses using a combination of experimental data and analytical and computational modeling. Improvements of at least 20% are sought. The Phase I should also address the change in manufacturing cost associated with any additional operation.

PHASE II: Develop, demonstrate and validate the surface engineering technique on vehicle powerplant and/or transmission components. Through a combination of analysis and experiment, evaluate achievable benefits of the surface engineering technique as compared to established baselines. Determine effectiveness of the treatment over ranges of speed and contact pressure typical of drivetrain components, and determine what specific applications would enjoy the largest efficiency improvements.

Determine any negative impacts the technology might have on component durability, and define a mitigation strategy. Establish a methodology for evaluating cost/benefit and develop estimates for payback time. Quantify efficiency improvements as compared to a baseline component, as well as durability.

PHASE III: Applications for the technology include propulsion systems for military air and ground vehicles, as well as commercial vehicle powertrains. High volume automotive manufacturing would provide an ideal application for these technologies to reduce cost and improve repeatability.

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KEYWORDS: Gears, transmissions, coatings, surface engineering, fuel economy, powertrain efficiency

A12-023 TITLE: <u>Solid Acid Electrolyte Fuel Cell</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop a solid acid electrolyte fuel cell that is hydrocarbon fueled and operates a elevated temperatures (>150 C). The fuel cell system shall produce over 50W electrical power for 500 hours with a system energy density above 1000 Wh/kg.

DESCRIPTION: The Army has need for high-energy density, lightweight power sources for the dismounted warrior. Currently methanol fueled polymer electrolyte based fuel cells and solid oxide fuel cells as being developed. Polymer electrolyte fuel cells often suffer from the need to manage membrane hydration levels to ensure adequate conductivity/transport. In addition, when polymer electrolyte membrane fuel cells are used with reformed hydrocarbon fuels the carbon monoxide must be removed to avoid poisoning the fuel cell catalysts. Solid acid materials such as $CsHSO_4$ or CsH_2PO_4 are proton conductors and preliminary results have been promising at temperatures as low as 200 C which eliminates carbon monoxide poisoning of the fuel cell catalysts. Lifetime of the solid acid materials has been a challenge to date, however, these systems offer the potential to enable direct use of hydrocarbon fuels.

PHASE I: In phase I a sub scale multicell solid acid electrolyte based stack will be developed and evaluated using hydrocarbon fuels. Stack performance data shall be evaluated and preliminary results from the stack should support the potential to develop a 50W system with a system energy density over 1000 Wh/kg.

PHASE II: In phase II, based on the results from the successful phase I program, design, construct, and evaluate multiple compact/light weight 50W fuel cell systems. The systems must have a lifetime exceeding 500 hours and a system energy density exceeding 1000 Wh/kg. Two systems will be delivered to the US Army for testing and evaluation.

PHASE III: Advanced solid acid electrolyte fuel cells offer multiple advantages over their polymer electrolyte membrane counterparts. This technology has the ability to impact both military and commercial applications. Both sectors are seeking compact light weight power sources for dismounted soldiers and civilian electronic devices. The solid acid electrolyte fuel cell technology has the potential to transition to both soldier borne and solider transportable applications to either power devices directly on the soldier or to serve as a power source to recharge secondary batteries. Likely sources of funding if the phase III program is successful include PEO Soldier and CERDEC.

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KEYWORDS: solid acid electrolyte, fuel cell, hydrocarbon fuel

A12-024 TITLE: Dislocation reduction in LWIR HgCdTe epitaxial layers grown on alternate substrates

TECHNOLOGY AREAS: Materials/Processes, Electronics

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

OBJECTIVE: Develop novel techniques to reduce the dislocation density to below 1E5 cm-2, in large area long wave infrared (LWIR, 8-12 microns) HgCdTe epitaxial layers grown on alternate substrates.

DESCRIPTION: The US Army is pursuing mercury cadmium telluride (HgCdTe)-based photovoltaic technology for high-performance, thermal imaging systems. Next-generation systems are envisioned to entail large-format (>1M pixels), infrared focal plane arrays (IRFPA). In order to be cost effective, it is highly desirable to have very large area HgCdTe epitaxial layers grown on commercially available 6-inch diameter Si substrates. Because of the lattice mismatch related issues, the dislocation density achieved in these epitaxial layers grown on Si substrates is only adequate for the fabrication of short wavelength infrared (SWIR, 1-3 microns) and medium wavelength infrared (MWIR, 3-5 microns) HgCdTe focal plane arrays (FPAs), but not for long wavelength infrared (LWIR) IRFPAs. Much more work is needed to reduce the dislocation density for suitability to produce high performance, high uniformity large density larger area Si substrate based LWIR HgCdTe IRFPAs

Recent work on ex-situ and in-situ thermal annealing (TCA) of molecular beam epitaxy (MBE) LWIR HgCdTe wafers grown on Cd(Se)Te/Si substrates [1-2] has demonstrated the reduction of dislocation density -as indicated by etch pit density (EPD), from E7cm-2 to E6cm-2. However, a saturation point appears to be reached where the HgCdTe/Si EPD does not decrease below 1E6cm-2 regardless of further TCA treatment or decrease in the as grown EPD value.

This solicitation seeks innovative solutions to reduce the dislocation density below E6cm-2 reproducibly and cost effectively to levels comparable to what can be achieved in LWIR HgCdTe epitaxial layers grown on lattice matched CdZnTe substrates.

PHASE I: Demonstrate the feasibility of the proposed innovation for EPD reduction below 5E5 cm-2 along with good electrical characteristics in epitaxially grown LWIR HgCdTe grown on Si substrates. A clear pathway to get the EPD below 1E5 cm-2 should be presented. Samples of LWIR HgCdTe on these substrates to be delivered to the Army for evaluation.

PHASE II: Demonstrate reduction of EPD below 1E5 cm-2 in large area HgCdTe epitaxial layers grown on 3 inch to 6 inch diameter Si substrates along with fabrication and characterization of LWIR HgCdTe detector arrays. Samples of epitaxial layers and device arrays to be delivered to the Army for evaluation.

PHASE III: Successful completion of Phase II, followed by validation of the innovative approach to reduce the EPD in LWIR HgCdTe grown on commercially available large diameter Si substrates will lead to commercialization of the approach to fabricate high performance large density LWIR HgCdTe FPAs fabricated in Si substrates suitable for many DOD applications.

Commercial applications include smog detectors, temperature arrays for weather satellites, and sensors for the examination of real time manufacturing yield, as well as various applications in astronomy.

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KEYWORDS: LWIR HgCdTe, Si substrates, large area, infrared detectors, photovoltaic, infrared focal plane arrays, thermal cycle annealing

A12-025 TITLE: <u>Tools for Adapting Computer Based Tutors to Commercial Games</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Research and develop methods to rapidly and automatically adapt tutoring systems (e.g., AutoTutor) to computer-based games.

DESCRIPTION: Today, computer games are an attractive option for training. Computer game elements, including logic, memory, visualization, and problem solving, cater to increasing learner engagement, interaction, and satisfaction. These elements are also required for the learning process. However, one limiting factor of computer games is their effectiveness as training systems due to their lack of credible feedback mechanisms in the absence of a human tutor. A tool to easily adapt and integrate existing tutoring systems (e.g., AutoTutor) with game parameters (e.g., player behaviors/actions) would go a long way toward expanding their use as training systems in the absence of human tutors. Such tools could also increase learner engagement and satisfaction during instruction on training systems.

PHASE I: Researches and defines innovative interfaces for automatically adapting prevalent open-source tutors to computer-based games. Determine the technical feasibility of and design a conceptual framework/architecture for a tutor-game combination interface. Provide detailed documentation of research, theoretical framework, technical feasibility, and design guidelines/standards for potential implementation (if applicable). If a tutor-game combination interface is not technically feasible, detailed documentation of justification is required. Such justification should include potential approaches and the technical challenges for each approach.

PHASE II: Develops a prototype automated game application interface and demonstrates its application with three example tutor-game combinations (e.g. AutoTutor and VBS2). Each example must vary domain or tutor/game combination. In addition to a working prototype, Phase II deliverables will include updated design documentation and testing results.

PHASE III: Commercializes toolkit to allow novices to interface computer-based tutors with commercial games. The commercialized toolkit should be applicable beyond the DoD arena.

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KEYWORDS: Adaptive Training, Serious Games, Intelligent Tutoring, ITS, Game Interfaces

A12-026 TITLE: Tools for Rapid Automated Development of Expert Models (TRADEM)

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Research and develop methods to rapidly and automatically develop expert models (also known as ideal student models) within computer-based intelligent tutoring systems.

DESCRIPTION: An expert model within an intelligent tutoring system (ITS) represents the domain's subject matter expert and problem-solving capability. Because expert models represent the highest level of competency in a training domain, they are a necessary element for adaptive training along with comprehensive student models. An expert model is compared to the learner's actions/selections during instruction to understand the learner's current competency of the domain. Some ITS expert models use rule-based approaches to generate problems, assess the learner's understanding, and demonstrate the correct solutions. However, such methods for developing comprehensive expert models are difficult and expensive. Today, expert models are painstakingly developed through manual task analyses. Future expert models should require less development time and allow for easier modification. Methods are needed to automatically develop instructional content, multiple paths to success, questions, instructional strategies and feedback in selected domains.

PHASE I: Researches and defines the salient characteristics of technologies (tools and methods) to mine web-based data sources to develop expert models. Develop and describe innovative methodologies to automate data collection and model development process. Determine the technical feasibility of and design a framework/architecture for an expert model builder. Provide detailed documentation of research, theoretical framework, technical feasibility, and design guidelines/standards for potential implementation (if applicable). If an expert model builder is not technically feasible, detailed documentation of justification is required. Such justification should include potential approaches and the technical challenges for each approach.

PHASE II: Develop a prototype expert model builder and demonstrate its efficacy in three complex training domains. In addition to a working prototype, Phase II deliverables will include updated design documentation and testing results.

PHASE III: Commercialize toolkit to allow teachers with some domain knowledge to develop expert models for use in computer-based training. The commercialized toolkit should be applicable beyond the DoD arena.

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KEYWORDS: Expert Models, Intelligent Tutoring Systems, ITS, ITS Tools, expert automation, Expert Observation, Expert Systems, Expert Toolkit

A12-027 TITLE: Data-Driven Architecture To Support Adaptable Training Systems

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Define and develop a methodology and software system capable of managing, organizing and facilitating fully-traceable Army knowledge relationships in support of training programs with defined performance objectives.

DESCRIPTION: TRADOC has published TRADOC Pam 525-8-2, "The US Army Learning Concept for 2015", which states that "the Army must take immediate action to develop a capacity for accelerated learning that extends from organizational levels of learning to the individual Soldier whose knowledge, skills, and abilities are tested in the most unforgiving environments." There is a challenge to maximize time on task training with limited training time, resources and manpower. Moreover, there is a need to provide the ability for efficient authoring of training to reduce the burden on the instructor. This topic focuses on methodologies to do the latter to inform the former.

Data-driven systems provide the ability to use and re-use existing data efficiently. They could provide the backbone to support an architecture that allows instructors to author dynamic content for students at an abstract level without having to worry about the training implementation. In turn, this topic focuses on methodologies to apply the data-driven approach to training in order to support:

- Rapid Training Aids, Devices, Simulators and Simulations (TADSS) Material Development
- Training Requirement Decomposition
- Training Requirement Traceability
- Related Training Topics
- Performance-based Tutoring

• Specialized Training Packages

The ultimate goal is a well-structured central database in order to ease subject matter capture, manipulation, access and maintenance across disparate training solutions, such as mobile devices, virtual worlds, etc. The software system should allow navigation of the data through intuitive and mutable knowledge relationships. The data and its organization should be independent of the views and navigation allowing multiple ingestion and export formats of the data elements.

PHASE I: In Phase I, the offeror will design a concept of a data-driven system capable of taking inputted data and then categorizing, organizing and deploying the data to disparate systems, such as mobile devices, virtual worlds, etc. focused on training applications. The offeror will define the form and content of inputs. Similarly, the offeror will choose sample systems for deployment. This effort will determine the feasibility of applying the data-driven approach to this training problem.

PHASE II: In Phase II, the offeror will develop, test and demonstrate the data-driven architecture in a relevant Army training environment, such as the ARL Simulation & Training Technology Center (STTC) Soldier-Centered Army Learning Environment (SCALE) effort. Though the architecture will be tested in a relevant environment, it should not be tied to this environment. In fact, the goal is for the offeror to demonstrate broad applicability during Phase II. The system should contain a separable data repository with organic relationships within the data elements facilitating navigation and machine-identifiable associated topics. Phase II deliverables will include data-driven architecture design documentation, test results and a working prototype implementation.

PHASE III: In Phase III, the offeror will apply the data-driven architecture to support TRADOC training applications, such as those planned via SCALE for the Institute of NCO Professional Development (INCOPD).

The offeror will examine other DoD integration points where data is evolving constantly and where the data and its internal relationships would benefit from being separate from its display, navigation and other relevant uses. One example is the gathering, organizing and understanding intelligence data via a separate mechanism that displays and alerts intelligence analysts.

The offeror will also work to commercialize this application as a solution for training authoring and deployment that would be applicable beyond just DoD application. For instance, such an application could support the teaching of automotive technicians who have constantly evolving technologies in each new year of models.

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KEYWORDS: Data-Driven Architectures, Training Authoring, Training Aids, Devices, Simulators and Simulations

A12-028 TITLE: Analytical Decomposition Capability To Support Live, Virtual, Constructive and Gaming Execution

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Define and develop a methodology and software system capable of decomposing analytical questions to support Live, Virtual, Constructive and Gaming (LVC&G) execution.

DESCRIPTION: There is a clear gap between the skills of the Army Analyst, Operations Research Systems Analyst (ORSA), and even the experiment director, and the simulation engineer. The former has great expertise in understanding operational phenomena and the goal of any given study, analysis or test. The latter has great expertise in configuring the simulations to specifications and in some cases informing what simulations have the necessary capability to the needs of the former.

The challenge lies in this translation from what the analytical group is truly trying to study to something that the simulation engineer can understand. In many cases, even a seasoned analyst may not be able to consider the second order effects of decisions made in the analysis space. Moreover, the specific question may seem like it is at a high enough resolution when it is in fact not.

This type of translation turns into a form of qualitative interview, looking to distill facts but also meaning from responses. The goal is an in-depth understanding of the how and why an analytical goal exists. Traditionally, quantitative methods have been applied to this decision space with little or no machine understanding, potentially leaving a gap in truly understanding the problem space.

This effort seeks an innovative approach to the problem of decomposing analytical questions into the parts necessary for LVC&G execution using a combination of qualitative and quantitative methods. The goal will be machine understanding capable of performing this decomposition that can be used in various analysis, experimentation, testing and training applications.

PHASE I: In Phase I, the offeror will design a concept of an analytical capability for decomposing analytical questions into the parts necessary for LVC&G execution. The offeror will explore cutting edge methods to fill this gap. This effort will determine the feasibility of designing machine understanding capable of performing this decomposition.

PHASE II: In Phase II, the offeror will develop, test and demonstrate the analytical decomposition capability in a relevant Army simulation environment, such as the RDECOM Modeling & Simulation (M&S) Decision Support Environment (MSDSE), the Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) Live, Virtual, Constructive Integrating Architecture (LVC-IA), the TRADOC Battle Lab Collaborative Simulation Environment (BLCSE) and/or ARL Simulation & Training Technology Center (STTC) Modeling Architecture for Technology, Research & EXperimentation (MATREX) effort. Though the capability will be tested in a relevant environment, it should not be tied to this environment. In fact, the goal is for the offeror to demonstrate broad applicability during Phase II. Phase II deliverables will include analytical decomposition capability design documentation, test results and a working prototype implementation.

PHASE III: In Phase III, the offeror will apply the data-driven architecture to support RDECOM MSDSE and TRADOC BLCSE events, LVC-IA training applications and/or MATREX research goals.

The offeror will examine other DoD integration points where the decomposition of analytical questions to LVC&G execution would be beneficial, such as the Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA(ALT)) System of Systems Engineering (SoSE) organization, TRADOC Analysis Center (TRAC) and Army Materiel Systems Analysis Activity (AMSAA). Furthermore, the offeror will explore DoD applications beyond just LVC&G, such as Systems Engineering.

The offeror will also work to commercialize this application as a solution for analytical decomposition that would be applicable beyond just DoD application. For instance, such an application could support the decomposition of customer needs for services in a number of industries, including manufacturing, landscaping and urban planning.

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KEYWORDS: Analytical Interview, Qualitative Methods, Analytical Decomposition, Live, Virtual, Constructive and Gaming Simulation

A12-029 TITLE: Biomimicry Based Azimuth Sensing

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Design and build a small, low cost, ultra low power, weapon azimuth sensing device that can determine dismounted soldier weapon aiming accuracy and provide aim accuracy feedback during simulated weapon on target tactical engagement training exercises.

DESCRIPTION: Weapon azimuth measurement is a key capability the Army possesses to simulate weapon on target tactical engagement training performed during live training exercises at home stations, training centers, and

during deployments. Weapon azimuth measurements are used to determine the geometric relationship, or aiming accuracy, between the shooter and intended target. Weapon aiming measurements are accomplished using sensors that to date provide unacceptable trade-offs - the need for high accuracy performance at the severe disadvantage of high cost, high power consumption, and excess weight. Users also deem the current technology to be marginal in terms of usability in the field because of the constant susceptibility to measurement errors that must be frequently removed through labor intensive field calibration. Current azimuth sensing technologies suffer from unacceptable trade-offs that has yet to be truly solved by industry. Even the latest Micro-electro Mechanical Systems (MEMS) technology adopted solely for miniaturizing mechanical proof mass (Coriolis) based gyros for example offers nano-scale advantages in terms of low power and cost but bias drift rate figures of merit still need to improve by almost a hundredfold in order to fulfill our requirements. A possible innovative approach to azimuth sensing could be to emulate nature's own design; various insects and birds for example are capable of sensing heading direction through their
specialized and highly efficient vision systems.

We seek an innovative approach to azimuth sensing that can yield a prototype device with an azimuth measurement accuracy of 1 milliradian, costs less than $100 in production quantities, consumes less than 150mW of power, occupies a volume under 10 cm3, requires no field calibration or initialization, and can maintain azimuth measurement accuracy during moments of high human dynamic motion.

PHASE I: Develop overall system design that includes specification for azimuth sensing that include planned end-user operating and environmental parameters.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over various outdoor operating conditions (i.e.; weather, cloud cover, day/night).

PHASE III: We envision adapting the product of this technology to transition to a broad range of military azimuth sensing and navigation applications particularly where size, weight and power consumption are critical - for example, in military laser target designators, weapon aiming measurement for mortar fire control systems, augmented reality training systems, and as navigation subsystems in small unmanned aerial or ground vehicles (UAV/UGV). Commercially for enabling outdoor capable motion capture and augmented reality.

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KEYWORDS: Sensors, biomimicry, celestial navigation, polarization compass, azimuth sensing

A12-030 TITLE: <u>Controlled Mobile Agents</u>

TECHNOLOGY AREAS: Information Systems, Sensors

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

OBJECTIVE: Develop novel methods to provide timely, relevant, and accurate information to enable real-time decision on semantic, temporal, and/or geospatial data source.

DESCRIPTION: Actionable information is a composite of intelligence and operational information, civil considerations, and information on the operational environment - Area, Structure, Construction, Organization, People, Events (ASCOPE); and Sewage, Water, Electricity, Academics, Trash, Medical, Security (SWEAT-MS) data. The integration of systems and formulating system of systems has significantly increased the quantity and fidelity of available data. The task of searching, collecting, and analyzing large volumes of disparate data to address a commander's time critical information needs can be overwhelming or merely best effort. The proposed technology will allow advanced analytics to move the computation across the network to distributed cloud data stores rather than the data to the computational resources of a large cloud node. Ultimately, advanced analytics will overcome network latency and offer quicker decision cycles.

The Offeror shall develop techniques for dispersing analytics across a defined Cloud architecture in a manner which is non-corrupting and non-interfering to existing network traffic. The effort should result in the ability to identify and produce specific data of interest for autonomous and persistent data mining within a defined networked environment. The effort will result in providing proactive information required for effective decision making within a data laden, networked environment. Furthermore, successful implementation shall allow data to be accessible (I can retrieve the data), available (all of the necessary data and information is present), and usable (in an appropriate format ready for consumption) for faster actionable decisions.

PHASE I: A study phase shall propose an analytics framework and architectural execution plan supported by the feasibility of the approach. It shall address the leveraging of existing algorithms and analytic techniques/ frameworks. The contractor shall deliver detailed descriptions of the analysis, results, and recommendations codified in a feasibility report.

PHASE II: Selection and implementation of the most promising algorithms, techniques, and framework shall occur in this phase. The contractor shall design, develop, and produce a prototype to address the problem. The contractor shall demonstrate the prototype in a relevant environment. The prototype shall be made available to the government for evaluation, verification and validation. The contractor shall deliver a detailed report of the effort and its results.

PHASE III: The required security and information assurance policies shall be addressed and certification for tactical employment shall be obtained. The developed system is intended to transition to PM DCGS-A CLOUD baseline. Additionally, the system can be employed in commercial enterprise where systems and/or facilities are distributed and/or implement CLOUD services. Additionally, the system should be employed in any commercial environment where secondary or tertiary information is required instantaneously and derived from large distributed data sets, e.g. marketing Educational savings plans to all home owners whom purchased homes with three or more bedrooms, in communities with good ratings for public school systems and are not delinquent in mortgage or property taxes.

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KEYWORDS: Analytics, Cloud, data mining, data processing, information management, advanced analytics

A12-031 TITLE: <u>Automatic Spoken Language Recognition for Machine Foreign Language Translation (MFLT)</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: The goal of this SBIR is to develop software that will have the ability to analyze an incoming audio signal, a human voice, and determine which language is being spoken. The approach will enable soldiers in the field to more effectively utilize Speech to Speech (S2S) Machine Foreign Language Translation (MFLT) systems in areas where multiple languages/dialects are being spoken in their Area of Responsibility (AOR).

DESCRIPTION: The warfighter has an extremely difficult task to perform with regards to communicating with local populations in theater. S2S MFLT technologies are a solution for communicating with individuals who are not native English speakers. S2S MFLT systems are software that utilize probability based algorithms to recognized spoken word, transcribe the recognized speech, translate the resulting text into foreign language text, and synthesize the resulting translated text into foreign language speech. Current implementations of the automatic speech recognition (ASR) software require the user to select, in advance of the translation, which foreign language will be used. ASR software is needed that incorporates audio signal and speech processing algorithms that will determine which language is being spoken.

Soldiers must continuously interact with the local populations of foreign countries even though they do not speak the native language(s). Currently, a number of S2S MFLT systems are in development, and have been deployed in theater with some success. However, current S2S capabilities require the soldier to know which language/dialect an individual is speaking before they are able to communicate with them via these S2S MFLT systems. This gap in capability exacerbates the already troublesome communication barrier, and in many cases leads to either a breakdown in communication, or can even cause the soldier to abandon communication attempts in order to access a human interpreter. The target languages for this project would be English, Arabic, Iraqi Arabic, Farsi, Pashto, and Urdu with the ability to add additional languages.

Although the military provides human interpreters in theater, these assets are expensive, sparse, and dangerous for the translators in wartime situations. The US ARMY has recognized that MFLT capabilities need to be developed and deployed to supplement this limited resource. Due to the multi-faceted nature of MFLT, and the current inaccuracy of these systems, there are many related sub-areas that currently lack relevant research and development. One of these relevant sub-areas is Automatic Spoken Language Recognition.

The goal of this SBIR is to develop software that will have the ability to analyze an incoming audio signal, a human voice, and determine which language is being spoken. The intended goal is for this determination to be used by existing S2S software to choose which Automatic Speech Recognition (ASR) / MFLT engine(s) to utilize in a given scenario. This approach will provide soldiers with a more robust S2S MFLT capability, thereby increasing translation accuracy.

PHASE I: The contractor shall determine the feasibility of using statistical and probability based algorithms to determine the language content of spoken word in real time. The feasibility study shall address various aspects of implementing Automatic Spoken Language Recognition including: Determining the feasibility of Automatic Spoken Language Recognition in English, Arabic, Iraqi Arabic, Farsi, Pashto, and Urdu, to include any signal or speech processing algorithms that may need to be enhanced or developed, and identifying a plan of action to achieve the stated capability in the form of a software application.

PHASE II: The contractor shall produce and demonstrate development of a prototype system ASR that is able to differentiate between English, Arabic, Iraqi Arabic, Farsi, Pashto, and Urdu speech. The system shall be provided as a software application installed on either a Windows OS laptop, or on an Android smartphone device with 2.2 OS. The contractor shall demonstrate the new capability by recognizing live speech and determining the source language.

PHASE III: The contractor shall provide software that will work in conjunction with a S2S MFLT system that will be determined prior to the beginning of Phase III. The resulting software will recognize the spoken language, and instruct the S2S MFLT system to utilize the appropriate ASR/MFLT engines. The resulting software will run on a smartphone device.

The prototype system will be subject to both laboratory and field evaluations to determine its viability. These evaluations will include both predetermined test scripts, and spontaneous speech in all of the targeted languages.

User feedback will also be recorded to determine the effectiveness of the capability in assisting bi-lingual communications.

It is envisioned that Automatic Spoken Language Recognition would be desired for other applications and agencies such as telemedicine and disaster relief who frequently coordinate with non English speaking populations.

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KEYWORDS: Language, Translation, Spoken, Recognition, Foreign, voice, Automatic, Speech

A12-032 TITLE: Mitigation of Range/Doppler Straddle for Radar Coherent Processing

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: Develop track-before-detect algorithms to provide greater signal processing gain for pulsed-Doppler radars.

DESCRIPTION: The proposed effort should develop novel signal processing techniques to provide longer coherent processing intervals (CPIs) than are conventionally thought practical in pulsed-Doppler radar. Due to target motion and/or acceleration, there are limitations to the coherent processing gain that can currently be achieved. Longer CPIs place more energy on the target and improve the signal-to-noise ratio (SNR), but they also increase the likelihood that a fast-moving target will move through multiple range gates over the interval, reducing the effectiveness of the integration process. With knowledge of the target set and appropriate motion compensation, it is believed these range/Doppler straddle effects can be mitigated; research literature suggests this can be a computationally-intensive process.

Given the rapid and continued advancement of processing hardware, more challenging approaches may be feasible. These approaches can allow for improved sensitivity (e.g. lower detection thresholds) by providing additional coherent processing gain. In doing so, lower radar cross-section (RCS) targets can be detected earlier in the trajectory without raising the false detection rate, thereby improving the ability of the radar to accurately track moving targets. Proposed solutions should have or show a growth path to near “real-time” performance (latencies of seconds, not minutes or hours). The proposed technique should also consider the effects of multipath and clutter in describing its potential capabilities.

Coupled with appropriate hardware/software, these new algorithms will be incorporated into currently fielded ground-based radars (AN-TPQ 48, AN/TPQ 49, AN/TPQ 50, and EQ-36), future systems (Omni-directional Weapons Locating (OWL) Radar), or into airborne ground moving target indication (GMTI) radars such as Forester.

PHASE I: The proposed effort will develop signal processing techniques to be used in next-generation ground-based radars to detect and track objects of interest. The contractor shall perform a feasibility analysis of the proposed technique on high-speed, low RCS targets. The contractor shall deliver a detailed report on the analysis, results, conclusions & a proposed feasibility plan to address this effort.

PHASE II: The contractor shall design, develop, and produce a prototype to address the problem. The contractor shall demonstrate the prototype and innovative signal processing technique proposed on a suitable test bed platform. The prototype shall be made available to the government for testing and evaluation; the verification and validation of the technical approach shall be achieved through analysis, simulations, and/or other quantitative means. The contractor shall deliver a detailed report of this effort and its results.

PHASE III: The completion of this phase would result in a mature technology which would undergo an appropriate operational demonstration, such as weapons location. The contractor shall integrate and validate the signal processing techniques developed and demonstrated in Phase II into an applicable platform, such as OWL. These mature signal processing techniques would have widespread utility and can be applied to current and future Army radars as well as commercial ground-based and airborne GMTI radar development efforts.

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KEYWORDS: Omni-directional Weapons Locating Radar, OWL, track-before-detect, coherent processing, range straddle, Doppler, motion compensation

A12-033 TITLE: Tactical Interference Cancellation Equipment (TICE)

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: To study the feasibility to develop signal interference cancellation techniques, hardware and software, resulting in a device that can be integrated into existing SIGINT receiver systems, to permit signal detection and processing in the presence of cosite interferes.

DESCRIPTION: Current military operations have demonstrated the impact of high power interference with respect to impeding C4ISR operations. A signal of interest (SOI) can be undetectable to receivers when signals of different powers are transmitted on the same/nearby frequencies or when an interferer is transmitting.

A new mitigation approach is required that can be applied to existing and future tactical mounted and dismounted systems with severe size, weight and power (SWaP) constraints, in a cost effective manner. The system must be able to handle a large frequency range, be applicable to different receivers, and be adaptable to cover the entire communication spectrum where possible. This program will demonstrate signal cancellation and mitigation techniques/hardware to improve the signal to interference ratio that can be integrated at the input of any receiver, e.g. this device would be placed in line between the system's antenna and RF input. It must be able to provide interference mitigation in the presence of cosite transmitters (high powered signals) and should have the ability to reduce high-powered and wide band signals to allow weaker signal detection. The device must have the capability to improve the signal to interference ratio to a minimum of ~10 dB without a significant effect on the automatic gain control (AGC) and noise figure of a receiver.

The device, when added to the input of the receiver, e.g. antenna port, must be able to provide interference mitigation in the presence of high powered signals to improve the signal to interference ratio to a minimum of 8 dB with minimal reduction in receiver sensitivity or effects on the signals. Analog and/or digital techniques should be used to produce a device that weighs less than 1 pound with a volume less than 50in3 while being low cost and low power.

Reaction time to the high-powered signal must be fast, e.g. nanoseconds, to prevent saturating the receiver's RF front end and to minimize the effects of the RF signal to the AGC. For applications, which require precise timing, amplitude, and phase information from multiple antennas, the mitigation techniques must allow the use of multiple interference cancellation devices for use in systems with multiple receivers and antennas.

The improved interference cancellation capability would allow current C4ISR operations to be continuously effective even in the presence of interferes and make better use of time and spectrum utilization. The completion of this effort will result in mature technology providing better situational awareness and intelligence in a "RF challenged" environment.

PHASE I: A system architecture and system specification should be designed for the device to provide interference mitigation in the presence of high powered signals while allowing missions to continue. Deliverables at the completion of this task should include a detailed final technical report on the feasibility of achieving the described design objectives.

PHASE II: Develop a proof of concept prototype that meets the requirements derived in Phase 1. The prototype signal interference cancellation device can initially be fabricated in a brass board format for demonstration purposes. A demonstration of the device's performance in a standalone configuration is required at the end of phase II. At the completion of this phase, the contractor shall deliver a detailed report, defining a final architecture that addresses performance, SWaP, and manufacturing concerns as well as its results. The contractor shall allow the government to have access to the prototype for testing and evaluation.

PHASE III: Development of this system could be utilized for a wide range of commercial products or for use by government agencies such as the FCC to find lower powered signals hidden in other high powered signals. Other possible transition areas could include PM PROPHET, USSOCOM, INSCOM, PM Command Post, and PMO Signals Warfare.

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KEYWORDS: Interference, Interference Cancellation, Communication, Sensors, Spectrum Management

A12-034 TITLE: Real-Time Handling and Planning System for Operational Decisions (RHAPSODy)

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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OBJECTIVE: Develop a real-time electronic warfare common picture capability. The capability will also provide a means of collaboration between Electronic Warfare (EW) operators and other Battle Command Functional Areas.

DESCRIPTION: The Proposed development is intended to provide a novel real-time/near-real-time (a few seconds), thin client collaboration and coordination capability and must integrate with the Distributed Common Ground System – Army (DCGS-A) system. This capability is intended to support the EW common picture / Battle Management and would provide the commander with greater and more flexible options to employ the most effective battle management strategy. Presently, collaboration environments exist, but provide data exchange via one way control and presentation of data, e.g. common picture display. Some existing collaboration capabilities are based upon proprietary systems and cannot be readily integrated with other battlefield functional area components. Moreover, these systems may require extensive hardware and stable communications architectures in order to effectively collaborate.

Ozone Widget Framework (OWF), Hyper Text Mark-Up Language 5 (HTML-5) and imPulse are the latest/next generation web technologies identified as viable thin client candidates. The SBIR is intended to leverage existing government science and technology investments such as the Ozone Widget Framework and imPulse (these products will be made available to the contractor as required). Utilizing one of the aforementioned web technologies (OWF, HTML-5, or imPulse), the contractor shall develop a novel thin client collaboration and coordination capability. The proposed solutions shall provide real time, bi-direction, simultaneous collaboration and be based on open standards for ease of integration. The proposed solutions shall not add any additional hardware to the intelligence and operational system thin client footprint.

PHASE I: The Phase I effort shall compare and contrast OWF, imPulse, and HTML-5 based upon their stability/maturity; real-time, bi-directional and simultaneous collaboration capability and quantity of data which can be shared. A recommendation of the most suitable candidate technology and its ability to provide a real-time collaboration environment shall be presented to the government at the conclusion of phase I.

PHASE II: The Offeror shall develop a prototype collaboration capability based upon the proposed web technology identified in phase I. The Offeror shall demonstrate the real-time collaboration environment within a suitable operational environment. The Phase II system shall be delivered to the government's Tactical Cloud Integration Laboratory (TCIL) for integration, demonstration and evaluation with representative tactical networks, IRON Symphony Army Technology Objective system network, Battlefield Functional Areas and DCGS-A enterprise components.

PHASE III: Phase III will address the incorporation of capabilities and interface requirements derived from user evaluation of the system. Additionally, the system will be hardened for operational deployment and address/ mitigate identified security gaps. The system will transition to the IRON Symphony ATO for further DOD hardening and integration. Additionally, the system will transition to PM DCGS-A to support collaboration across Battlefield Functional Domains. The developed system will be employable for commercial use as applicable, such as water treatment plants, medical systems, and municipal agencies.

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KEYWORDS: EW, Collaboration, Real-time, HTML 5, collaboration, semantic web, data architecture

A12-035 TITLE: Helicopter Hostile Fire Indicator (HFI) Sensor Development

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: To detect and classify ballistic unguided munitions (subsonic and supersonic) at distances up to 100 meters from Army rotary wing aircraft, using low-observable sensor technology.

DESCRIPTION: The US Army has a requirement to detect and classify hostile fire ballistic unguided munitions in proximity to Army rotary wing aircraft. This sensor capability will provide situational awareness of hostile fire to the aircrew. The sensor is required to be low-observable, low power, light weight and highly reliable. Ultra-wide band technology may be a possible solution. The sensor shall provide the capability to detect, classify, and provide location information for hostile fire ballistic unguided munitions at distances up to 100 meters from the aircraft.

The sensor size needs to be less than 1 cubic foot, weigh less than 45 pounds, power less than 425 watts, and be able to operate on a dynamic rotary winged platform.
Aircraft AC power characteristics: MIL-STD-704F (400 Hz, 115/200 volt AC system)
Power characteristics reference: http://www.wbdg.org/ccb/FEDMIL/std704f.pdf

PHASE I: Identify design methodologies and critical design parameters for an HFI system for rotary winged platforms. Develop an initial system design and concept that achieves the requirements and capabilities. The result from Phase I will be a feasibility study for this system. The contractor shall deliver a detailed report on the analysis, results, conclusion and a feasibility plan to address this effort.

PHASE II: Build a prototype for the HFI detector to validate and mature the system design solution that addresses the requirements stated above. Evaluate key elements of the system in a laboratory environment. The prototype shall be made available to the government for testing and evaluation. The contractor shall deliver a detailed report of its efforts and its results.

PHASE III: Development of the system will be transitioned to the HFI community. The commercial applications for this system are Homeland Security Systems, police force protection, and commercial helicopter protection. Low cost technology may be able to improve tactical vehicle, dismount, and fixed-site gunshot and RPG detection systems.

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KEYWORDS: Ultra-wide Band, Low Observable, Sensor, Airborne Survivability Equipment, Threat Detection, Hostile Fire Indicator, Ballistic

A12-036 TITLE: Enhanced Operator Situational Awareness for Multi-Unmanned Vehicle Teams

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

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop new technologies to enable an unmanned vehicle operator to rapidly understand the state and activities of large, semi-autonomous, air/ground unmanned vehicle teams sufficiently to enable quick and effective mission level decisions.

DESCRIPTION: Current unmanned vehicle operator control units (OCU) are designed primarily for single vehicle tele-operation. While functional, these OCUs provide a narrow window into the situation in which the vehicle is operating and are often cluttered with low level details that are only marginally relevant to the current task. Thus unmanned vehicle operation is less intuitive and more labor intensive than desired and is ineffective for multi-vehicle teams.

The future of unmanned vehicles is a shift from direct tele-operation to supervised semi-autonomous systems and eventually toward full autonomy in which a single operator may oversee mission execution by a team of vehicles. In such an environment, the operator would be able to specify high level tasks, monitor mission status, and update mission goals, while autonomous mission planning/execution services handle the lower level platform interaction. To support this type of role for the operator, development is needed of an innovative OCU display that allows the operator to understand both the global picture (e.g. the map and vehicle locations in space) as well as important dynamic events (e.g. encounters with threats, distress). During execution, the Soldier must remain cognizant of current mission status and any changes in the operational environment to avoid information overload and degradation of mission performance. Furthermore, such a system could be linked to existing databases such as the Tractical Ground Reporting (TIGR) system to link current events to prior reported events or collected data.

Solutions will be required to address a subset or all of the following research issues:
• Effective and efficient mechanisms for display of unmanned vehicle team status, environment, and system situation awareness. Especially important is the ability to help the user understand and address uncertainty due to imperfect sensing and task execution.
• Methods for segregating and displaying data based on the current situation including aggregating and filtering incoming data to avoid distracting the operator.
• Automating situation recognition and display adaptation to proactively provide operators with detailed information for important situations.
• Enabling two-way situation awareness (SA) where the operator can correct or otherwise reconcile SA with the vehicle team.

Solutions should also incorporate modern display interaction techniques such as touch and gesture. Consideration should be paid to various form factors such as surface computing devices (e.g. at battalion or higher echelons) or smaller, tablet form factors for smaller units or vehicle teams. However, to the extent possible, the core concepts, algorithms, and visualizations of proposed solutions should be not be dependent on any particular hardware device.

PHASE I: Develop a design for an intelligent OCU emphasizing operator situational awareness for a multi-vehicle team. Research relevant technologies for display, user interaction, sensor data management, and uncertainty management. Develop measures of performance and analyze design tradeoffs. Provide visualization mockups, algorithm descriptions, and system specifications. Identify risks and develop and implementation plan.

PHASE II: Implement a prototype of an intelligent OCU. Integrate and test this prototype within a relevant simulation and/or a small team of unmanned vehicles using, wherever possible, open standards such as the Joint Architecture for Unmanned Systems (JAUS). Demonstrate the OCU's capabilities against key measures of performance, emphasizing the minimization of operator interaction time and ability of operators to successfully complete missions with a team of unmanned vehicles.

PHASE III: Mature and rigorously test the intelligent OCU technology in appropriate test and operational environments. Integrate with military operational unmanned vehicles. Adapt technology for other, non-military operations such as homeland security or law enforcement.

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1. Endsley, M.R. (1996) Automation and situation awareness. In R. Parasurman & M. Mouloua (Eds.), Automation and Human Performance: Theory and applications (pp. 163-181). Mahwah, NJ: Lawrence Erlbaum.

2. Prasanna Velagapudi, Paul Scerri, Katia P. Sycara, Huadong Wang, Michael Lewis, Jijun Wang: Scaling effects in multi-robot control. International Conference on Intelligent Robots and Systems 2008: 2121-2126

KEYWORDS: Unmanned, Operator Control Unit, Decision Aid

A12-037 TITLE: <u>High Speed and Low Operating Voltage Laser Q-Switch</u>

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: Fast optical deflector or modulator Q-switch with a low drive voltage. The device will modulate the optical loss in a solid state laser resonator cavity. The device should be capable of transitioning between the "on" state and the "off" state in a time of less than 10 microseconds.

DESCRIPTION: Currently, Q-switched lasers used for designation, marking, and range-finding use either active electro-optic crystal Q-switches, or a saturable absorber passive Q-switch. The first is optically efficient but requires a costly and bulky high voltage pulse generator, while the second is simple to use but introduces significant optical loss into the laser cavity, resulting in low laser efficiency. These deficiencies could be avoided with the availability of a fast and compact mechanical deflector mirror based on Micro-electro-mechanical (MEMS) type mirror deflector or another type of modulator. When placed into the laser resonator, such a fast deflector results in generation of Q-switched pulses when its angle momentarily aligns to cause beam propagation to be parallel to the optical axis of the laser resonator. The potential advantages of MEMS Q-switches are low optical loss, low cost and simple low voltage drive electronics.

PHASE I: Demonstrate relevant performance characteristics in a breadboard modulator. If the device is a deflector type, then the deflection angle should be at least 1 mRadians or 0.06 degrees. If the device is an intensity modulator type, then the "off" state attenuation should be at least 15 dB. The optical aperture should be at least 3x3 mm and the modulator should handle pulse energy of at least 30 mJ for 10 nanosecond pulses at 1064 nm with a repetition rate of 20 Hz. The modulator or deflector should introduce less than 1/10 wavelength phase distortion and less than 5% optical loss for the optical beam in the "on" state. The drive voltage should be less than 250 V. The company is expected to deliver monthly reports along with simulation code and calculations.

PHASE II: Develop, build and deliver 20 optimized Q-switch modulators, that are ruggedized, compact (less than 1 cu. in., not including the driver) and work over a temperature range of -40 to +60 degrees Celsius.

PHASE III: The devices should be ruggedized to be compliant with MIL-STD-883H Mechanical Shock, (Method 2002.5, Test Condition D) and MIL-STD-883H Vibration Fatigue (Method 2007.3, Test Condition). Device will be capable of integration in the Compact Laser Marker program. Dual use applications include laser rangefinders, lasers for LADAR mapping systems, and lasers biomedical applications.

REFERENCES:

1) "Compact laser sources for laser designation, ranging and active imaging." Proceedings of the SPIE - The International Society for Optical Engineering 27 April 2007, vol.6552, no.1, pp. 65520G-1-8. ISSN: 0277-786X (print), CODEN: PSISDG Publisher: Orlando, FL USA: SPIE - The International Society for Optical Engineering Country of Publication: USA. Goldberg, L.1; Nettleton, J.1; Schilling, B.1; Trussel, W.1; Hays, A.1. US ARMY, Night Vision Lab. & Sensors Directorate, Fort Belvoir, VA, 22060, USA.

2) "Monoblock laser for a low-cost, eyesafe, microlaser range finder." Applied Optics, Vol. 39, Issue 15, pp. 2428-2432 (2000) John E. Nettleton, Bradley W. Schilling, Dallas N. Barr, and Jonathan S. Lei

3) Laser Designators and Seekers - Field Evaluation Results, https://www.dtic.mil/ Technical Report - StintFile116315_201103280901.

4) Compact Laser Marker HELLFIRE and PAVEWAY Seeker Field Evaluation, https://www.dtic.mil Technical Report - RDER-NV-TR-274.

5) Compact Laser Marking Tests, https://www.dtic.mil Technical Report - RDER-NV-TR-271.

KEYWORDS: Lasers, Q-switches, beam deflectors, modulators, MEMS

A12-038 TITLE: Extended Range Low Power Personnel Detection and Classification Sensor

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: To conceive, design and build a low power sensor that uses on-board processing to detect and classify dismounted humans at extended ranges day and night with a low rate of false alarms.

DESCRIPTION: Soldier workload in a potentially hostile environment can be significant. Tasks that require a Soldier’s constant vigilance in anticipation of a significant event are a type of activity where the application of technology can be a meaningful force multiplier. Twenty-four hours a day monitoring of a border or a passage point for human activity is one such task. A long range very low power personnel detector that could be emplaced and left unattended for months at a time could perform a function that now requires continuous human eyes on the area or point of interest. The sensor would need to reliably detect and classify humans who enter the field of view or area the sensor is monitoring and provide an alert. It would need to operate twenty-four hours a day and in all weather conditions. It would need to be low cost to allow many sensors to theoretically be strung in series to observe an area such as a border. The desired output is simply a signal that the sensor has detected and classified human presence. The desired power consumption would be less than 100mW to facilitate long term operation on a reasonable size battery pack in areas where use of solar panels would be precluded by either foliage or the need to be more covert. The desired sensor range to detect and classify humans is out to 300 meters.

An output signal would indicate presence of a human. A communications system to transmit that signal is not part of this effort.

PHASE I: Develop a design, using appropriate modeling and analysis, for a low cost prototype sensor with low power onboard processing capability. Provide sufficient analysis, possibly to include a breadboard sensor, to give confidence the prototype system would produce adequate signal to allow detection and classification of a human at 300 meters in starlight conditions, 5e-9 watts/cm^2. If a passive infrared linear array approach is used, the sensor must put be designed so that a human would subtend at least 16 vertical pixels at 300 meters. The Government would provide guidance concerning algorithms that would operate on the prototype sensor's output data to detect dismounted humans in varied environments.

PHASE II: Complete sensor development and fabricate prototype sensors based on the Phase I design. Port Government provided algorithms to the low power processor. Deliver a report on contractor testing and results. Deliver two complete systems to the Government.

PHASE III: The vision of the end-state of the research is a low power consuming remote sensor that reliably detects and classifies human presence day/night at a range of 300 meters using hardware/firmware developed under this SBIR integrated with Government provided algorithms. During Phase III the contractor can expect to support Government conducted field tests of the integrated sensor systems. These field tests will be conducted to verify performance in a variety of relevant environments. The sensors developed in Phase II shall be upgraded as necessary. Commercialization of these sensors will be applicable to both military and law enforcement needs. Military applications include persistent surveillance and use in support of area denial operations. The systems will also be useful in border monitoring applications by the Department of Homeland Security as well forest and wildlife management and any situation requiring remote property surveillance using low cost unattended personnel detectors.

REFERENCES:
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2. Hao, Q., Brady, D., Guenther, B., Burchett, J., Shankar, M., Feller, S., "Human Tracking With Wireless Distributed Pyroelectric Sensors," IEEE Sensors Journal, Vol., 6, No. 6, December 2006

3. Jacobs, E., Chari, S., Halford, C., McClellan, H., "Pyroelectric Sensors and Classification Algorithms for Border/Perimeter Security," Proceedings of SPIE, Electro-Optical and Infrared Systems: Technology and Applications VI, October 2009

4. Jakowatz, C., Smiel, A., Eichel, P., "Pyroelectric line scanner for remote IR imaging of vehicles," Proceedings of SPIE, Infrared technology XIII, August 1987

5. Jenkins, F., White, H., Fundamentals of Optics (McGraw-Hill Book Company, 1950)

KEYWORDS: sensor, human detection, low power processing, thermal, passive infrared, optics

A12-039 TITLE: Electroless Plating of Indium Bumps for High Operating Temperatures (HOT) Mid-Wave (MW) Sensors

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: This solicitation seeks a manufacturable process to fabricate flip-chip indium bumps via electroless plating. The targeted platform to insert electroless indium bumps will be midwave infrared (MWIR) high operating temperature (HOT) focal plane arrays (FPAs), which have been demonstrated for both III-V (nBn) and II-VI (MCT) materials systems. Therefore, this process should be compatible with such materials, as well as the readout integrated circuits (ROICs) such FPAs are hybridized to. Chemicals or processes that potentially compromise, corrode, or leave residue on components are undesirable.

DESCRIPTION: There is a continued push to scale down the pixel pitch of FPAs for military applications. Reduced pitches allow for higher-resolution, larger-format arrays capable of seeing further down range and are useful for persistent surveillance applications. Because Indium bumps form a one-to-one interconnection between each pixel of an infrared FPA and each unit cell of a ROIC, their pitch must be scaled down accordingly. The current Indium bump fabrication process typically involves a thick negative resist liftoff where the Indium is deposited by thermal evaporation. While this process has been used successfully for many years, a variety of limitations, including deposition pinch-off and crystallite formation, make further scaling down challenging. Electroplating of indium bumps has been explored and offers solutions to many of these scaling problems. However, indium deposited by electroplating is granular, affecting the consistency of bump morphology. Obtaining high lateral uniformity of bumps is challenging due to edge effects during plating. Also, the electroplating process is complicated by the necessity of a suitable under bump material that must be blanket deposited and later removed after plating. Electroless plating, whereby a chemical reduction process is used to deposit the desired material without the use of electrical power, has distinct advantages over electroplating or evaporation. For other metals, manufacturable films with uniform thickness, even on complex shapes and structures have been produced using this process. Such a process has not been realized to this date for indium. Therefore, developing an indium electroless plating process for flip-chip bumps would be a substantial innovation that has not been achieved before.

HOT MWIR sensors are attracting attention because of increasingly stringent size weight and power (SWaP) requirements and the possibility of enhanced cooler life. Because such FPAs will likely play a key role in future combat systems, insertion of an innovative indium bump process potentially maximizes the impact of this program.

PHASE I: The goal of Phase I will be to develop an electroless indium plating process applicable to hybridization of nBn and MCT FPAs, with the following quantitative targets: indium bump pitch of 12 microns, indium bump thickness of greater than 6 microns, and thickness uniformity of 5%. The process should not compromise FPA or ROIC materials. Confirmation of this through experimentation and documentation should be included. By the end of Phase I a 256x256 mechanical array of electroless plated indium bumps fulfilling the above quantitative targets should be produced, along with delivery of the mechanical array to the Army for further testing.

PHASE II: Phase II includes two main thrusts. The first of these is to reduce the pitch of electroless indium bumps down to 8 micron pitch or lower while maintaining the other quantitative targets listed in Phase I. Delivery to the Army for independent testing of a 512x512 or larger format mechanical array of electroless plated bumps that achieves these targets will be required six months into Phase II. By the end of the first year of Phase II, connectivity testing of a 512x512 or larger format array of hybridized bumps will be required, along with delivery of the hybridized part to the Army for further testing. Mechanical parts may be used as long as statistical information of the connectivity can be obtained. The second main thrust of Phase II will be to insert the electroless plating process into the hybridization of HOT MWIR FPAs. Connectivity testing of two hybridized HOT MWIR FPAs to appropriate ROICs (all of which to be obtained by the contractor), with at least a 512x512 format at a pitch of 15 microns or less using the electroless indium bump process will be required. Additionally, delivery of these parts to the Army for further testing and demonstration will be required. The first delivery will be required eighteen months into the program and the second at the conclusion of the program. The goal at the end of Phase II will be to achieve connectivity of greater than 99.9% on the hybridized FPA.

PHASE III: The goal of Phase III will be to transition this indium bump fabrication technology to a HOT MWIR FPA fabrication line. This technology also has the potential to be inserted into all types of FPA fabrication lines as well.

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1. W. Zheng and L. Wu, Preparation and characterization of indium films by electroless plating under hydrothermal conditions, Journal of Materials Science Letters, Volume 19, Issue 18, 1611-1613.

2. Y. Shachamdiamand, V. Dubin, and M. Angyal, Electroless Copper Deposition for ULSI, Thin Solid Films, Volume 262, Issue 1-2, 93-103.

3. M. Datta, S.A. Merritt, M. Dagenais, Electroless remetallization of aluminum bond pads on CMOS driver chip for flip-chip attachment to vertical cavity surface emitting lasers (VCSEL's), IEEE Transactions on Components and Packaging Technologies, Volume 22, Issue 2, 299-306.

KEYWORDS: indium bumps, flip-chip, electroless, MWIR, high operating temperature, infrared, focal plane arrays,

A12-040 TITLE: Novel Approaches to Buried Explosive Hazard (BEH) Detection using Electromagnetic Techniques

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: The US Army has a need to detect buried explosive hazards across a wide range of environmental conditions, in various terrains, at depths from flush buried down to a meter or more, and in mounted and dismounted configurations. The objective of this research is to investigate advanced sensor and signal processing concepts that enable effective BEH detection that address US Army needs.

DESCRIPTION: The CERDEC Night Vision and Electronic Sensors Directorate is interested in advanced concepts for using electromagnetically-based interrogation techniques to detect buried explosive hazards, which can be completely non-metallic, have some metal content, or a significant metal content. BEHs in this context include the explosive device and all related components including initiators, power sources, connecting wires, and associated components. Detection modalities of interest include electromagnetic induction (EMI) and ground penetrating radar (GPR) and thus the frequency range of interest is approximately 1 kHz to 10 GHz. Broadband frequency ranges are of interest for both EMI and GPR sensor types. GPR signals down to 300 MHz are desirable for deeply buried hazard detection, but practical antenna size should also be considered in the design tradeoff process. Novel sensing and processing techniques are of interest with the aim of detecting BEHs at depths including flush buried down to depths of one meter or more. Current Army GPR capabilities are limited to detecting shallow buried targets for both vehicle mounted and handheld sensor configurations. Sensor modalities for detecting either shallow buried targets or deeply buried targets will be considered since the optimal frequency bands for each depth category may not coincide. Also of interest are techniques that provide a capability to accurately estimate the depth of the detected objects, techniques that accommodate surface irregularities (e.g. potholes, tire ruts, vegetation, etc.) and positive and negative ground surface inclines, and techniques which allow for motion compensation when sensors are mounted on moving ground based platforms. Analysis tools to help characterize sensor performance and to help characterize effects on performance of factors such as antenna bounce, target depth, sensor platform speed, and techniques for assessing the effectiveness of fusing sensor modalities such as electromagnetic induction and GPR are also needed.

PHASE I: Develop the proof-of-concept and a breadboard design. Design variables should be defined, modeled and documented as applicable. Relevant data must be used for design analysis and understanding of variables. Laboratory level experimentation will be required to obtain necessary data if not available from open sources. Software and signal processing efforts will be demonstrated on actual or simulated data.

PHASE II: Complete construction of the technology demonstration apparatus or software/signal processing module. Extensive testing in laboratory and realistic field environments will be performed to confirm and/or adjust results of analyses and models completed in Phase I. Technology demonstrator will be used to perform field tests with representative targets or using data that includes representative targets.

PHASE III: Demonstrate prototype technology in warfighter surrogate environments against real target types. The use of this technology would be applicable to the DoD and various humanitarian efforts for countermine/IED purposes. Opportunities are available to transition successful products to ongoing and planned Army programs for handheld and vehicle mounted IED and mine detection. This technology has numerous potential dual use applications in asymmetric warfare, airport security, border security, and utility companies.

REFERENCES:
1. A host of information regarding the current state-of-the-art in buried explosive hazard detection can be obtained through the following conferences: SPIE Defense and Security Symposium (Detection and Remediation Technologies for Mine and Mine-like Targets Session) in Orlando, FL; Mine Warfare Conference; and UXO Detection and Remediation Conference.

KEYWORDS: sensors, sensor fusion, ground penetrating radar, antennas, metal detection, signal processing

A12-041 TITLE: Advanced Order Linearizer for Satellite Communications

TECHNOLOGY AREAS: Electronics, Space Platforms

OBJECTIVE: Design, develop, and fabricate a high order linearizer for satellite communications that enables an active device to operate at or near saturation and sustain linear characteristics. The high order linearizer will be capable of reducing artifacts of device non-linearities, while significantly improving Amplitude Modulation to

Amplitude Modulation (AM-AM), Amplitude Modulation to Phase Modulation (AM-PM) conversion, Power Added Efficiency (PAE), and reduce Adjacent Channel Power Ratio (ACPR).

DESCRIPTION: Power Amplifiers (PA) for satellite communications exhibit nonlinearities, requiring an operating point that is backed off from the maximum output power, resulting in reduced PAE. Power amplifier nonlinearities severely impact amplitude modulation to phase modulation conversion, distorting certain Phase Shift Key (PSK) class communications waveforms, increasing Error Vector Magnitude (EVM). These nonlinearities also adversely affect the ratio of energy in the carrier to the carrier side bands. The increase in sideband energy requires additional guard bandwidth, which is unused for communications. Nonlinearities are mitigated by backing off saturated output power by 4 - 6 dB (typical, depending on PA technology), resulting in linear AM-AM, sub 2.5 deg/dB AM-PM, and -30 dB ACPR. This mode of operation is extremely inefficient, requiring the PA to be sized larger than needed. Low order (3rd) predistortion linearizer technology have been used to slightly reduce output power back off to 2.5 – 4 dB, resulting in the same typical AM-PM and ACPR. This SBIR topic is seeking an innovative, above 3rd order adaptive and/or digital predistortion linearization solution to improve artifacts of intrinsic PA nonlinearities. Linearizer solution will allow power amplifier to operate with less than 1.5 dB (threshold) | ~0 dB (objective) output power back off, less than 2.5 deg/dB AM-PM, and greater than -40 dB (threshold) | -50 dB ACPR (objective) [Where the carrier side band is defined between +/- 1-1.5 times the symbol rate]. It can be assumed that the waveform will be an M-ary PSK class waveform, with maximum bandwidth of 26 MHz (objective) | 52 MHz (threshold). The linearizer solution will be capable of operating on a 30-31 GHz and 43.5- 45.5 GHz PA, not necessarily simultaneously. It is desired that solution is portable (stand-alone), and can be integrated into other PA applications.

PHASE I: Design a concept(s)/topology for an Advanced Order Linearizer. Perform an analysis on linearizer topology; demonstrating ability to meet system level criteria, model and simulate predicted performance, identify processing (or circuitry) associated with topology, identify feasibility and risk associated with implementation. Analysis should also include but not limited to, the impact to topologies performance with multi-carrier performance. Investigate trade-offs of key performance parameter against topology implementation.

PHASE II: Design, test, demonstrate, and deliver two prototype Advanced Order Linearizers. Prototype will operate on a 30-31 GHz and 43.5-45.5 GHz PA. Prototype will be tested with PA, showing test results for AM-AM, AM-PM, and ACPR with and with-out linearizer. Prototype will be demonstrated with 26/52 Msps M ary PSK class waveform showing ; less than 1.5 dB (threshold) | ~0 dB (objective) output power back off, less than 2.5 deg/dB AM-PM, and greater than -40 dB (threshold) | -50 dB ACPR (objective) [Where the carrier side band is defined between +/- 1-1.5 times the symbol rate]. Delivered prototype is expected to have a technology readiness level of six (6).

PHASE III: The Advanced Order Linearizer prototype design will be refined, optimized, and productized for stand-alone operation. An Advanced Order Linearizer has the potential for use on Warfighter Information Network-Tactical (WIN-T) and Defense Communications and Army Transmissions (DCAT) Wideband SATCOM Terminal Systems (WSTS). The maturation and transition of this technology into these satellite communications systems will greatly improve communications link performance, power and spectrum efficiency. Successful commercialization/productization of an Advanced Order Linearizer, provides paralleled benefits to private sector commercial satellite communications, and private sector point to point microwave communications. This technology can also be leveraged by portable manpack solutions, requiring high efficiency battery conserving technology.

REFERENCES:
(1) Cripps, S. C., Advanced Techniques in RF Power Amplifier Design, Norwood, MA: Artech House, 2002

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KEYWORDS: Digital Predistortion, Linearizer, Linearization, Power Amplifier, Adaptive, Predistortion

A12-042 TITLE: Variable Magnification Clip-On Thermal Imager (COTI)

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: Identify the most cost effective method of optically performing sensor fusion of thermal long wave infrared with other non-unity optical devices such as scopes, binoculars, and cameras. The emphasis is to develop an approach such that a Clip-On Thermal Imager (COTI) device can be used in a multitude of applications where the optical system has high and /or variable magnification.

DESCRIPTION: For the warfighter, the sensor technology gap between US forces and their adversaries has narrowed. In order to regain an overmatch capability, the warfighter must be able to quickly detect, target, or record potential targets and threats at various ranges in low light and/or obscured scenes. This new capability has been proven using a COTI to Night Vision Goggle (NVG) based devices. However, the current systems require that a unity magnification COTI be mounted to a unity magnification NVG. There are many situations where a binocular, rifle scope, or other higher power magnification systems could benefit from a COTI capability. This new device may require some type of optically varying magnification, an optically variable injection system, a variable display system, an e-zoom capability, or most likely some combination of all these features. The key will be to develop a flexible system that at the same time keeps the size, weight, and power (SWAP) as near as possible to the currently optimized COTI features.

PHASE I: Identify, evaluate and compare innovative concepts for an optically fused thermal imaging module that can be used on different optical systems such as binoculars, scopes, and cameras. The key system parameters to be investigated shall include cost, weight, power consumption, resolution, predicted thermal or combined imager range performance, and imager field(s) of view. Additionally, the engineering research shall address the level of compatibility of the optical overlay concepts with legacy hardware. The impact of the optical overlay concept on the legacy hardware inherent performance shall minimize the loss of contrast, resolution, sensitivity and field of view.

The following parameters represent goals of the new system:
Size/Vol: 3.75” x 3” x 1.5” / 5.5 in3
Weight: < 175 gms (w battery)
Battery Life: > 3hrs with no external battery pack
Optical Magnification Ranges: 1 to 3x, 3x to 10x
I2 Device Objective Lens Diameter: 15 mm to 40 mm

PHASE II: Fabricate, and deliver an optical overlay imaging demonstration prototype system based on the results of the Phase I research. Test the prototype at an appropriate Government test center for issues and required improvements. Complete a CDR for the fabrication of the product necessary to go into future formal Government Testing.

PHASE III: Based on the design developed in Phase 2, fabricate an appropriate quantity of units to Support Government conducted field tests of the optical overlay imaging demonstration prototype. These field tests will be conducted to assess optical performance parameters at the component and system level. Provide design and engineering analysis of laboratory and field test data in a final report. This technology is applicable to both military and law enforcement organizations. Commercialization of the variable magnification clip-on thermal imaging system will be directly applicable to local police, search and rescue, firefighting and border patrol operations. All of these non-military applications have multiple devices of varying magnifications that would benefit dramatically from a clip-on thermal imaging module.

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2) Brown, J., and S. Horn, "Microsensor technology: the Army's future force multiplier," Proceeding of SPIE, Infrared Technology and Applications, XXXV, Orlando, FL 1999.

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4) http://www.defenseindustrydaily.com/Through-a-Glass-Darkly-Night-Vision-Gives-US-Troops-Edge-06047/

KEYWORDS: Clip on Thermal Imager, Night Vision Goggles

A12-043 TITLE: Context Independent Anomaly Detection for Enhanced Decision Making

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: The contractor shall design and develop a Context Independent Anomaly Detection (CIAD) software process to provide enhanced decision making using intelligence, surveillance, and reconnaissance (ISR) sensors. The CIAD is a software-enabled automated process to combine, refine, reduce, exploit, and transform significant volumes of data from a wide variety of ISR sensors and other sources, from tactical to cultural and economic into tailored, timely and relevant information useable by soldiers and automated tools to support improved conceptual representation, understanding, assessment, prediction, and intuitive decision-making in complex and uncertain environments. The CIAD integrates fusion and decision support technologies into a single unified process that will reduce latency, bandwidth, and redundant manual processes and functions while increasing the effectiveness of force application, whether kinetic, non-kinetic, or cognitive. The CIAD will provide an automated mechanism for analyzing vast amounts of data generated by today's ISR systems for the purposes of isolating anomalies that identify threats. Asymmetric threats pose a particular concern because the analyst may not have any predetermined search criteria available to effectively review the vast quantities of raw data in order to isolate the data related to the threat. The context independent techniques developed by this effort will enable the soldier to rapidly search significant volumes of ISR data in real-time and isolate anomalies to be evaluated as threats without having any pre-existing knowledge about the threats. The application will be capable of running in real-time and will operate on a diverse set of sensor data. The data products produced by the CIAD will directly contribute to enhanced decision making related to force application, countering enemy actions, and interdicting enemy forces.

DESCRIPTION: A Context Independent Anomaly Detection (CIAD) application provides the war fighter with a process to effectively and efficiently search significant amounts of ISR data and other sources, from tactical to cultural and economic for anomalies that indicate potential threats. A traditional search engine requires the operator to know key words or other related data context prior to the search, with the results of the search being closely coupled to the quality of the search criteria. The context independent search requires no prior understanding of the data but instead identifies trends and structure within the data to isolate nonconforming occurrences, referred to as anomalies, to be extracted and reviewed in further detail. Due to the enormous amount of data that ISR sensors can produce, the CIAD applications need to be designed and implemented to run in near real-time and use techniques that can handle very large data sets. The data products generated by the CIAD process must contribute to enhanced decision making for the war fighter in terms of identifying threats in complex environments and providing information to allow the efficient and effective application of force to counter those threats.

PHASE I: Perform a design study to formulate innovative technical approaches to develop a CIAD application that operates on ISR data and other sources, from tactical to cultural and economic to support enhanced decision making. The design study should define the paradigm for anomaly detection and explain in detail how the approach is independent of a priori understanding of data context. The CIAD design should be compatible with a wide variety of ISR sensor data and other sources, from tactical to cultural and economic as well as data fusion inputs. Complete a CIAD design concept and demonstrate through modeling or analysis that it meets the requirements of improved decision making in the ISR domain for threat analysis and application of force.

PHASE II: Use the results of the design concept generated in Phase I to develop a detailed software model of the CIAD for use with ISR sensor systems. The model should include ISR sensor data, both real and simulated, and other sources, from tactical to cultural and economic to exercise the CIAD and demonstrate its functionality. Use the software model of the CIAD to perform a demonstration that validates that the approach improves situational awareness and decision making for the operator.

PHASE III: Implement the CIAD as part of the Distributed Common Ground System - Army Joint Maritime Protection System (DCGS-A/JUMPS) environment and deploy the system for test and evaluation. The implementation should operate in near real-time and be adaptable to multiple types of ISR sensor data, other sources, (tactical to cultural and economic and fused data). Test cases should be designed and executed to demonstrate the viability of the approach. Potential applications include maritime domain awareness and border security missions.

The technologies developed in this effort are directly applicable to law enforcement and homeland security missions including border patrol and counter narcotics missions. Additionally, the technology can be adapted to the financial and IT markets where computer fraud and malicious behavior needs to be identified and traced without prior knowledge of the threat.

REFERENCES:
1. Data Mining – Concepts and Techniques; Jaiwei Han and Micheline Kamber; 2006

2. Unsupervised Anomaly Detection System For NIDS-S Based On Payload And Probabilistic Suffix Trees; Iñigo Perona, Olatz Arbelaitz, Ibai Gurrutxaga, José I. Martín, Javier Muguerza, Jesús M. Pérez; 2008

KEYWORDS: Anomaly Detection, Fusion, Decision Making, Intelligence, Surveillance, Reconnaissance

A12-044 TITLE: Intelligent PMESII Information Management Workbench

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a human-centered computational tool that helps to guide an individual or group of collaborating warfighters though the PMESII (Political, Military, Economic, Social, Infrastructure and Information) aspects of mission analysis that supports active search, organization, and exploration of accessible data and information that assists the user in formation of situational awareness of their environment. The tool will use existing interfaces (including smart agents) to retrieve data and information for study and manipulation, and will focus on the development and analysis of relationships between seemingly diverse and unrelated data and information that result in a better understanding of PMESII factors.

DESCRIPTION: Investigate a multimedia, multi-modal workspace that enables a user or a collaborative group of users to be actively and intelligently supported with relevant data/information that highlight potential key elements and relationships between entities that the user identifies as germane to their current mission context across the multi-dimensional space represented by PMESII. The system should automatically recognize user entered entities/concepts and suggest information within the user's local and available information stores that is context relevant to the user's workflow. Develop a human-computer interface (HCI) that is intuitive to the user, allowing a novice user to perform mission-relevant tasks within one hour. As users become more proficient, the HCI will model user data and relationship presentation preferences, enhancing the intuitive nature of the workspace. System should capture the results of these active information explorations as knowledge products that could be potentially shared within the enterprise. Develop an initial design that describes how this model would be integrated into the Army Command and Control environment, including typical or reasonable surrogate systems. Investigate software architecture, network, and database issues associated with the development and deployment of the proposed model.

The goal of this effort is to provide planners a mechanism to actively support the hybrid (human-computer) development of the complex interactions between identified entities in the PMESII domain for a particular area of operations that allows them to maintain situational awareness as they develop courses of action guided by doctrine given in "The Commander's Guide to Money as a Weapons System." Ultimately, this project could serve as a building block for the larger challenge of providing a modeling capability across the entire PMESII-PT (Political, Military, Economic, Social, Information, Infrastructure, Physical Environment and Time.) This capability is at the heart of determining what is required to support tactical human terrain knowledge and how to support holistic data-to-decision frameworks for Counter-Insurgency (COIN) and Stability Operations environments.

PHASE I: The goal of phase I is to establish the fundamental research for innovative theories, tools, and systems leading to a methodology that solves how the described problem will be addressed. Expected focus areas for this research include applicable data items, as well as an assessment of their relationships and hierarchies. A representative workflow using a subset of data and a subset of the problem space will be developed. Additionally, a clear and concise methodology (i.e., the theory) that enables more comprehensive development will be presented. Data visualization techniques, sharing of workbench results and database, architecture, and software considerations will be investigated. The deliverables for phase I will include a research report describing the research effort and the design of the proposed methodology, a workflow analysis with two detailed use cases, and an analysis of development and deployment issues.

PHASE II: The goal of phase II is a proof of concept for a particular PMESII-PT domain that will be provided by the government. The contractor will also demonstrate that the proposed methodology can effectively be readily executed on new areas of interests for which a PMESII-PT domain exists. The deliverables for phase II will include the working prototype for the initial domain, a subsequent successful demonstration of the prototype on a new domain, and a demonstration of the portability of the methodology to new domains. The developed solution must be lightweight (easily installable on a standard Microsoft Window workstation). The phase I theory/methodology should be revisited and updated as appropriate based on findings from the phase II development. A roadmap for inclusion in a Tactical Operating Environment, considering software, database, and architecture issues, shall also be delivered. The contractor should also supply experimentally validated data that supports the system's applicability.

PHASE III: The goal of phase III is to demonstrate the ability of the system to effectively help warfighters in different areas of interest. Demonstrated progress towards fielding of a PMESII Information Workbench system into a Tactical Operational Center environment is expected. Applications for the Federal Emergency Management Agency and the Department of Homeland Security could also be targets.

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4) M. Endsley, Design and evaluation for Situational Awareness Enhancement," Proc. Human Factors Soc. 32nd Annual Meeting, 1988, pp.97-101.

5) United States Army Number 09-27, April 09, "The Commander's Guide to Money as a Weapon System", U.S. Army Combined Arms Center.

KEYWORDS: PMESII, PMESII-PT, human-centered, situational awareness, Counter-Insurgency (COIN), Stability Operations

A12-045 TITLE: Improved Mobile User Objective System (MUOS) Metaferrite Based Antenna for SATCOM

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

OBJECTIVE: Antenna size is a prohibiting factor when trying to integrate UHF communication systems into many army air platforms such helicopters or Unmanned Aerial Vehicles. Integration space is limited on these platforms due to moving parts such as rotors, the size of the vehicle, and the clearance to the ground when landing. UHF antennas are typically on the order of 2 feet in length for efficient performance, antennas currently integrated into these platforms are typically 8 to 11 inches in length due to platform size constraints. This size constraint makes the antennas very inefficient, and thereby limits the range or throughput of communication. This is particularly challenging in satellite communications, where reducing the range to the satellite is not an option, and reducing throughput greatly impacts the quality of service. The objective of this program is to determine the reductions in the aperture area and ground plane thickness that can be produced by incorporating isotropic metaferrite composites into UHF TACSAT apertures.

DESCRIPTION: The use of metaferrites to decrease the size of antennas has recently been successfully demonstrated for a number of linearly polarized antennas. MFs were used to reduce the depth of a cavity-backed crossed dipole (CBD). In this demonstration the antenna size was reduced from 6’’ to ¼’’ with the same performance over the 200 MHz to 500 MHz band. This and other demonstrations show the effectiveness of this technology to reduce antenna size. One of the challenges that remain is that metaferrites are anisotropic. For this reason they can effectively reduce the size of linearly polarized antennas, but cannot effectively reduce circularly polarized antennas. UHF satellite communications for MUOS are circular polarized. Under this SBIR isotropic metaferrite materials will be developed for this application. This SBIR directly supports the Breakthrough Antenna Technologies ATO, which is investigating the use of metaferrites for a variety of antenna applications. The materials developed in this SBIR will be utilized in BAT antenna apertures for demonstration of UHF TACSAT communications. Through this partnership of aperture development under the BAT ATO and isotropic metaferrites developed under this SBIR, the objective can be met.

PHASE I: The Phase I effort will result in an analysis of material properties necessary to effectively reduce the size of a circularly polarized antenna in the MUOS band. Simulations of a MUOS antenna aperture with these materials inserted will be accomplished.

PHASE II: Phase II will result in the delivery of isotropic metaferrite material tailored for the MUOS application.

PHASE III: This technology is applicable to military and commercial antennas designs where size and depth limitations must be overcome. This technology is expandable to ground and dismounted antennas where it can decrease visual signature and increase mobility. In particular, a significant potential military applications for this technology is UHF SATCOM. Significant potential commercial applications are in wireless handsets at frequencies below 1 GHz. These handsets could be transitioned to military tactical cellular handsets.

REFERENCES:
1. Kern, D.J.; Werner, D.H.; Lisovich, M.; Metaferrites: using electromagnetic bandgap structures to synthesize metamaterial ferrites, IEEE Transactions on Antennas and Propagation (2005)

KEYWORDS: Antenna, metaferrite, metamaterial, aviation, MUOS, UHF, TACSAT, reduced visual signature

A12-046 TITLE: Embedded Co-Located Antenna Elements to Increase Pattern Coverage and Effectively Mitigating Interference for Improved Communications

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Placement of antennas on aviation and ground platforms results in decreases in pattern coverage due to limitations in available mounting locations and the need to avoid cosite and parasitic interference. Typical antennas operate over a single or limited number of bands. This results in multiple apertures being mounted on a platform to support the various radio systems. A solution to this problem is to consolidate several antenna elements into a single structure. To reduce interference between the elements and facilitate collocated apertures, antenna elements will be embedded within one another such that elements are RF transparent to frequencies outside their band of operation.

DESCRIPTION: To enable multiple elements to be co-locating, this SBIR will develop a method to incorporate elements that are non-conductive at frequencies outside their bands. This program will develop a five-band antenna consisting of embedded RF transparent structure for aviation platforms. The elements will be embedded within one another such that they form a single structure. The five elements will cover the one of each of the following bands: 30-88 MHz for SINCGARS, 116-174 MHz for VHF AM / ATC, 225-400 MHz element for UHF-AM / HAVEQUICK, 450-512 for Public Service, and 1200-2500 MHz for WNW / SRW. The unit must meet or exceed current antenna performance parameters, such as gain, efficiency and bandwidth, for all bands. A power supply may be used in the RF transparency control of the elements. This effort will support the Leap-Ahead Aviation Antenna Technology (LAAT) project that is developing antenna prototypes that incorporate advanced technologies to improve bandwidth, gain, and pattern coverage. This SBIR will also act as a risk mitigator for the future antenna ATO.

PHASE I: Design antenna aperture to include five elements, power module, and matching and feed network and demonstrate a proof of concept. The Phase I proof of concept can be demonstrated using appropriate electromagnetic simulation tools (e.g., using FEKO, CST Microwave Studio, HFSS, etc).

PHASE II: Develop antenna aperture to include SINCGARS, VHF High, UHF-AM, Public Service, and L-Band plasma elements, power module, and matching and feed network. Construct air-worthy prototype and conduct realistic testing on-board aviation platform.

PHASE III: This technology is applicable to military and commercial antennas designs where space or mounting locations are limited and expandable to ground and soldier/civilian radios. A particular potential military application is for multi-function antennas for reduction of radar crossection in air platforms. A potential commercial application is for base station antenna sites that have exhausted possible antenna locations.

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KEYWORDS: Antenna, embedded, RF Transparent, cosite, aviation, SINCGARS, VHF AM / ATC, UHF-AM / HAVEQUICK, WNW / SRW

A12-047 TITLE: Resources Management in Peer-to-Peer Mobile Ad Hoc Network Communications Environments

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Design and develop the infrastructure-less peer-to-peer (P2P) mobile ad hoc network (MANET) management protocol for resources management in dynamic mobile environments applicable for both tactical and commercial MANET.

DESCRIPTION: New approaches are needed for management of resources of the infrastructure-less mobile ad hoc network (MANET) where each mobile node is autonomous and works in peer-to-peer (P2P) fashion. It requires automated on-the-move (OTM) reconfiguration, and operates in severe resource constraints (e.g. limited battery power, variable link quality, and limited storage capacity). A good number of MANET routing protocols have emerged such as RFC 5614 MANET Extension of Open Short Path First (OSPF) using Connected Dominating Set (CDS) Flooding and RFC 6130 MANET Neighborhood Discovery Protocol (NHDP). The objective of this proposal is to have the mobile ad hoc network management protocol solve the resource management problems in dynamic OTM environments where the network topology changes through the breaking of links and creating new links as nodes. This is important because all warfighter networks, along with some commercial vehicular networks, are targeted for using the MANETs and the most challenging of this task is the MANET routing protocols that are being developed. The MANET management protocol development is very critical to make the MANET deployment a reality because the classical simple network management protocol (SNMP) is not applicable for the MANET. The MANET resources management protocol needs to accommodate the topology management based algorithms and discovery schemes such as used in RFCs 5614 and 6130. Like SNMPv3, the security schemes also need to be articulated in view of dynamic mobile environments.

PHASE I: Develop overall detail specifications of the peer-to-peer (P2P) mobile ad hoc network (MANET) management protocol for resources management in dynamic mobile environments including management information based (MIB).

PHASE II: Develop and demonstrate a design of protocol in a realistic environment. Conduct testing to prove feasibility over the peer-to-peer (P2P) mobile ad hoc network (MANET).

PHASE III: This MANET resources management protocol could be used in a broad range of military and civilian communications applications where mobile vehicles/cars/unmanned vehicles/aircrafts will be moving in ad hoc fashion over roads and/or air forming the infrastructure-less peer-to-peer (P2P) mobile ad hoc network (MANET). The end state of this research activity is to define the MANET Management Protocol that can be used for management of resources of the radios, wireless links, routers, application servers, and other functional entities that are used tactical MANETs such as in Army WIN-T. This MANET Management Protocol (MMP) developed in research state will be transitioned for using Army WIN-T MANETs in operational environments. The same management protocol can be used for any commercial MANETs such as in mobile vehicular ad hoc network (VANET). Finally, the MMP could be standardized in the public standards organizations like IETF, ANSI, and others.

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2. Chen, Wenli, et el, ANMP: Ad Hoc Network Management Protocol, IEEE Journal on SAC, vol. 17, no. 8, August 1999.

3. IETF RFC 5614 MANET Extension of Open Short Path First (OSPF) Using Connected Dominating Set (CDS) Flooding.

4. IETF RFC 6130 MANET Neighborhood Discovery Protocol (NHDP).

5. IETF RFCs 5590-92 related to Simple Network Management Protocol version 3 (SNMPv3).

KEYWORDS: Mobile Ad Networks (MANET), Peer-to-Peer (P2P), On-the-Move (OTM), Connected Dominating Set (CDS), Neighborhood Discovery Protocol (NHDP)

A12-048 TITLE: Advanced Small, Lightweight Multi-Fueled 1,000 - 1,500 W Variable Speed Load Following Man-Portable Power Unit

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To design, develop and demonstrate an advanced small, lightweight (45 lbs (Threshold) and 35 lbs man portable (Objective)) multi-fueled (JP8 / DF2 / Gasoline), 1,000 - 1,500 W variable speed, load following man-portable power unit that can provide 120VAC continuous output for mission load, 28 VDC continuous output for mission load and for 28 VDC output for battery recharging via a three way selectable switch. This man-portable power unit shall take advantage of recent advances in small lightweight high speed internal combustion engines which include but not limited to unmanned aerial vehicles (UAV) engines. The power unit designs will be based on the evaluation, modification/upgrade, and integration of commercially available engines and state of the art alternator, power electronics, fuel processing techniques, thermal management and composite materials for packaging. An operating life of approximately 2500 hours (Threshold) and 3500 hours (Objective) is desired for engines in this power range.

DESCRIPTION: The Army is in need of a small, lightweight multi-fueled man-portable power unit capable of producing 1,000 W to 1,500 W of continuous power at 28 VDC and 120 VAC and of operating on middle distillate fuels, such as JP8, DF2, and on Gasoline. This power unit shall enhance ground force effectiveness, flexibility, protection and freedom of movement by reducing the need to transport fuel; improving utility and local management of energy resources; and enhancing unit resilience in the face of uncertain energy situations. Power in this range shall not only reduce the logistic footprint but reduce the sorties to refuel theater vehicles which expose Soldiers to enemy engagement during the mission.

The application of emerging nanomaterials based solutions for combustion and power electronics are desired. These materials are seen as a means to optimize combustion, to reduce component and system size/weight through improved thermal management and heat transfer within power electric modules, and to increase power conversion efficiencies by 20% and increase subsystem life and reliability. Application of state of the art techniques and advanced materials which improve/enhance the overall durability of small, high speed engines, alternators, power electronics, thermal management, and composite materials for packaging are sought. Component life is a cost driver for any system. The target is to field a power unit with an operating life of at least 2500 hours (Threshold), 3500 hours (Objective).

The operational and performance goals for an “Advanced Small, Lightweight Multi-Fueled 1,000 - 1,500 W Variable Speed, Load Following Man-Portable Power Unit” shall include:

Weight: 35lb [15.9 kg] (Threshold); 45 lbs [20.4 kg] (Objective)
Power Output: 1,000 to 1,500 W (1.0 PF) continuous variable speed output up to 4,000 feet (1219.2 meters), 95ºF (35ºC) with no degradation.
Voltage: 120 VAC, single phase, 60 Hz; 28 VDC; Switch Selectable
Power Quality: MIL-STD-1332B, Utility, Class 2C; MIL-STD-704F;
EMC: MIL-STD-461
Noise: Less than 72 dBA @ 7 m [22.9 ft] (Threshold); 70 dBA @ 7 m [22.9 ft](Objective)
Fuel: JP8, DF2 & Gasoline
Start Up: pull start down to -10 oC (14 oF)
Protective Devices: as needed for safe operation and to prevent damage to the engine, alternator, power electronics, and controls:

- Output Short Circuit Protection
- Overload Protection
- Thermal Sensing and Shutdown
- Under Voltage, Over Voltage
- Over Voltage, Over Current
- Over Frequency, Under Frequency
- Over Temperature

Fuel Consumption: 0.26 gal/hr [0.98 l/hr](Threshold); 0.20 gal/hr [0.76 l/hr](Objective)
Operational Life: 2500 Hrs (Threshold); 3500 Hrs (objective)
Environment: start, stop, and operate at sea level with no degradation of power output from -32ºC (-25ºF) to +60ºC (+140ºF) at any possible relative humidity.

PHASE I: The contractor shall identify potential fuel processing techniques (i.e. composite materials, advanced atomization, vaporization, catalytic partial oxidation (CPOX) techniques, etc.) that optimize the high speed internal combustion engines and shall determine the optimum design options for engines. Techniques identified should be compatible with the use of middle distillate fuels such as kerosene, JP8 / DF2, and gasoline. The contractor shall also explore / identify / specify existing and future permanent magnet alternator designs, power electronic topologies, system controls, nanomaterials for thermal management and composite materials for packaging to satisfy the Army’s operational and performance goals for an Advanced Small, Lightweight Multi-Fueled 1,000 - 1,500 W Variable Speed, Load Following Man-Portable Power Unit.

PHASE II: Using the Phase I design, the contractor shall develop and fabricate two (2) proof of concept “Advanced Small, Lightweight Multi-Fueled 1,000 - 1,500 W Variable Speed, Load Following Man-Portable Power Unit”. Prior to the fabrication of the proof of concept, the Contractor shall conduct durability testing on the selected engine to provide confidence that life enhancement would be accomplished. After completion of durability testing, the contractor shall fabricate two (2) proof of concepts for electrical characteristic testing. The proof of concept system must be demonstrated to have the ability to start and operate on JP8/DF2/Gasoline and provide full continuous output power from 1,000 to 1,500 W at 120VAC or 28 VDC.

PHASE III: Commercial migration of the Phase II Design: the contractor shall finalize the development of the Advanced Small, Lightweight Multi-Fueled 1,000 - 1,500 W Variable Speed, Load Following Man-Portable Power

Unit. The contractor shall also identify target markets for applications and industry partners for production to minimize cost.

Develop partnerships with Army Project/Program Offices to enable opportunities for fielding to support future forward area soldier and tactical platforms. The results from the Phase II effort will afford the contractor the capability to provide US Army and the DOD a new advanced state-of-the-art small, lightweight multi-fueled 1,000 - 1,500 W variable speed, load following man-portable power unit. The resulting system can be transitioned to Increment 2 of the Ground Soldier System (GSS) acquisition program, executed by the Project Manager Soldier Warrior (PM SWAR), the FY15 "Small Tactical Electric Power (STEP) Program" which is executed by the DoD Project Manager for Mobile Electric Power (PM-MEP).

REFERENCES:

1. Army Regulation 70-38, Research, Development, Test and Evaluation Of Material For Extreme Climatic Conditions

2. RDECOM Technology of Areas of Interest – High priority capability and technology gaps with suggested technology areas for developing FY12 programs.

KEYWORDS: Power Electronics, Permanent Magnets, Unmanned Aerial Vehicle Engine, Multi-Fueled

A12-049 TITLE: Novel Methods To Develop Graphene Obscurant Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a very highly conductive, graphene flake that can be used as an infrared obscurant. These ultra thin graphitic layers will have to be atmospherically stable down to 20nm thickness. Ideally, this material would need to be dispersed individually as an aerosol but initial research to test proof of concept could be in suspension. The desired physical dimensions of an infrared obscurant would be a flake having a major dimension of 5 to 10 microns, with a minor dimension of 20 to 40 nanometers. Cost effective processes and scalable methods would need to be established to make this a viable obscurant replacement.

DESCRIPTION: Obscurant materials are used by the Army to protect both the soldier and his equipment. Several obscuration systems have been developed over the years to counter various threats in many areas of the electromagnetic (EM) spectrum. Historically, work has focused on infrared (IR) and visible (VIS) signature-reducing materials individually. With the new threats and sensors, requirements have been established for devices to defeat both types of threats using a single, low-toxicity and highly effective material. Graphite flakes have been used on large area screening systems and offer very low toxicological footprints. However, for volume-limited packaging applications, such as hand grenades, graphite materials typically have not performed as well as metal materials due to their low conductivity. Therefore, the standard M76 brass grenade was developed. But the toxicological and environmental concerns are so great that training with these devices is very restricted. A carbon-based material that offers extremely high conductivity is needed to meet these new emerging requirements as well as the political policies of low environmental impacts.

PHASE I: Develop and synthesize highly conductive graphene flakes with the desired thickness of 10 - 20 nanometers and major dimension of 5 - 10 microns. Measure and document the size of the flakes. Develop a procedure to determine the conductivity of the graphene flakes. Develop means to package the materials that will facilitate efficient aerosolization. Initial studies could be performed in solution, but the goal is to develop a dry powder. The objective would be to produce a powder that has a packing density of 50% of the theoretical maximum and that can be aerosolized into a cloud consisting of 50% of the packed materials as individual flakes in their original dimensions. Perform optical tests to determine the infrared screening performance. Graphite flakes typically have an extinction coefficient of 2 m2/gm, which should act as a baseline. These tests can be conducted at ECBC or ECBC personnel can offer guidance to allow contractor to perform them. Consideration should be given for fabrication techniques that are low cost and that lend themselves to scale up, while maintaining the performance of the material. Deliver at least one 10-gram sample of graphene flakes for evaluation.

PHASE II: Continue with cost effective scale up of material development and fabrication. This phase should concentrate on developing novel ways to aerosolize the materials developed in Phase I. Focus on developing processes that will produce enough materials to fabricate several full-size hand grenades based on the M106 geometry. Since effective dissemination of these materials or any other materials is a problem within itself, several concepts should be investigated. Researchers can start with the explosive mechanism of the M106, but unique pyrotechnic or pressurized air systems should be investigated. A testing matrix should be developed to determine which type of dispersive system works best for these materials. Would strongly encourage in-situ particle generating processes or novel ideas and concepts to separate densely packed fill materials. Any strategies to increase packing fractions and device yields will improve overall obscurant systems performance and reduce logistics burden. Optimized dispersion techniques will be necessary for the next generation obscurant systems. Deliver a five kilogram lot of materials in packaged form for evaluation.

PHASE III: This product is a material that can be integrated into current military applications: Electromagnetic Interference (EMI) shielding, vehicle parts and combat uniforms. New military application would be infrared threat sensor countermeasures. Industrial applications for a highly conductive graphene material include electronics, fuel cells/ batteries, furnaces and others.

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4. Chan, H.E., Graphene and Graphite Materials; Nova Science Pub Inc (Mar 2010)

5. Moskvitch, K., Graphene Technology Moves Closer, http://www.bbc.co.uk/news/technology-13886438 (2011)

KEYWORDS: aerosol, graphene, highly conductive, obscurant, graphite

A12-050 TITLE: Novel method for filling graphite microfibers

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: To develop a viable method for filling a hollow graphite microfiber with a continuous, highly-conductive metal.

DESCRIPTION: Currently graphite fibers are regularly produced with diameters ranging from tens of nanometers to microns. Graphite fibers have many military and industrial applications because of their strength, wear resistance, and optical properties. Certain fabrication techniques result in a hollow fiber. This may offer an intriguing opportunity for their use as an obscurant. If this hollow fiber could be filled with metal, it would result in very high obscurant performance. The metal fill will have to be continuous along the entire length of the fiber (at least five microns for infrared attenuation). With the metal encased in graphite, there is a decrease in toxicological and environmental impact. It also reduces the amount of metal per fiber, thereby increasing the buoyancy of the obscurant material and the performance on a mass basis. In addition, the fiber is stronger; with the graphite on the outside, the metal is less likely to fracture and to disrupt conductivity. Finally, the graphite surface is relatively inactive, which will make the fibers more likely to separate.

PHASE I: Obtain or produce hollow graphite microfibers with diameters in the 50-200 nanometer range and having lengths of several micrometers. As an alternative core material, a non-conductive hollow fiber with these dimensions will work. This fiber must be strong enough to maintain its length during packing and dissemination. Develop a procedure to fill the fiber with different high-conductivity metals. Demonstrate with appropriate methodology that high electrical conductivity (iron or better) exists along the entire length of the fiber. Produce 5- to 10-gram quantities of the metal-filled graphite fibers - in dry form, preferably. Perform optical tests to determine infrared screening performance (can be performed at ECBC). Fibers should achieve an extinction coefficient of 10 m2/gm or better. Note that attenuation efficiencies are achieved only if the fill itself has high conductivity, that is, there will be a minimum effective fill diameter (probably requires several nanometers). Deliver at least ten 10-gram samples with different fibers, fills or processes.

PHASE II: Scale up metal fill process to produce kilogram runs and perform product quality tests. These tests would have to determine that 90% of fibers have continuous conductivity (iron or better) for a length of at least 5 microns, that 90% of fibers are not attached to each other, and that 50% of fibers maintain their original dimensions during aerosolization. Aerosol chamber tests will be conducted to measure the infrared attenuation performance and to characterize the fibers. Fibers should achieve an extinction coefficient of 10 m2/gm or better. In Phase II, a design of a manufacturing process to commercialize the production of low-cost metal nano-filled graphite microfibers will be developed. A method for packing and aerosolizing the fibers will be developed. Objective goals are that 50% of the theoretical packing density is achieved and that 50% of total packed fibers are disseminated as singles in the aerosol. Deliver at least five 1-kg samples with different fibers, fills or processes that meet performance objectives.

PHASE III: This product is a material that can be integrated into current military applications: electromagnetic interference (EMI) shielding, vehicle parts and combat uniforms. A new military application would be an infrared threat sensor countermeasure. Industrial applications for the metal-filled graphite microfibers include electronics and fuel cells/batteries, among others.

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KEYWORDS: hollow graphite microfiber, metal filling of voids, infrared attenuation

A12-051 TITLE: Wind Energy Systems for Base Camp Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To develop a rugged, redeployable wind energy system for use in military base camp applications that can be packaged, shipped, and deployed from TRICON shipping containers. Cost per watt and capable operational conditions are the key focus areas.

DESCRIPTION: Utilization of wind energy offers great potential to dramatically lower the military's reliance on JP-8 and Diesel fuels. This reliance becomes a further issue as the logistical burden increase with the remote nature of Combat Outposts (COPs) and Platoon Expeditionary Camp (PEC) sized Forward Operating Bases (FOBs).

Unlike solar energy systems, wind energy systems can operate 24 hours a day. The hindrance with wind energy often comes with cut-in speeds, or the wind speed in which the system can operate, which is why many systems must be at a high altitude. For military applications, a low cut-in speed is desirable to allow for low system heights, even if the ability to produce power may be slightly less at those speeds. Some wind energy systems lend themselves to having a low cut-in speed and a high cut-out speed, such as vertical axis wind turbines (VAWT), and to a degree, diffuser augmented wind turbines (DAWT). Turbines of this style also offer advantages in their significantly lower profile than typical horizontal axis turbines, which results in lower radar interference with VAWT/DAWT designs [1].

Though some attractive concepts may currently exist, there is significant room for improvement to develop promising wind systems to the level in which the military will consider the solution as a reasonable investment (lightweight, low cost per watt). A characteristic of a resultant wind power solution would be its ability to utilize a hybridized microgrid of solar, wind, and combustion power generation. Though eventually for use in a microgrid, a solution to this solicitation must be able to operate as a standalone power generation system.

An acceptable wind energy system for a small FOB must be ruggedized, redeployable from being packed in a TRICON shipping container [2] (no permanent construction, concrete, etc.), contain efficient energy storage methods (ex. batteries), and have a reasonably low cost per watt. As mentioned, a larger operational range, a lower cut-in speed, and low overall system cost will create a more relevant system for military use.

PHASE I: Develop a wind energy system concept that can be stored and deployed from a TRICON shipping container. The maximum total system weight, including the TRICON weight, must be less than 10,000 pounds (lower is strongly preferred). An acceptable system is expected to be far from approaching this system limit unless significantly justified; a very lightweight system is highly desired. The system should not require any external input other than wind to operate. Ideally the cut-in speed for a system will be near 10 MPH and a cut-out speed above 60 MPH. It is desirable to have no less than a 300W rated power at cut-in speed, meaning at the lowest operational speed the system should produce 300W. The wind system will likely be deployed on unlevel ground; this is a key design factor to be addressed in Phase I. Deliverables expected from Phase I are a detailed system concept which can meet the described specifications and a scaled performance model of the proposed system in relevant conditions. The scaled model should demonstrate deployment method and proof of concept for any unique system characteristics.

PHASE II: Phase II will focus on developing full scale prototype systems based on the detailed concept system provided in Phase I. The prototype system, including energy storage, must be fully integrated into and deployed from a single TRICON shipping container. Phase II prototypes will be subjected to range of military testing for durability and power production performance.

A successful full-scale Phase II prototype will need to meet multiple military requirements. The ruggedized wind power system must be deployable within 30 minutes by 2 warfighters without the use of special tools or heavy equipment. An acceptable system should be durable enough to withstand and function with no loss of performance after 25 erect/strike cycles. Wind systems may be deployed in close proximity to shelters and therefore must maintain a low noise level (Level F or below) in accordance with MIL-STD-1474D Requirement 1 Steady-State Noise, Personnel Occupied Areas. The wind system must be able to operate in applicable extreme environmental conditions in accordance with MIL-STD-810G.

At the conclusion of a Phase II contract a TRICON deployable, low cut-in speed system is expected to cost in the range of $4 per watt (or $4000/kW). This allows for the system to have a cost advantage over other renewable source, mobile, power solutions and also be competitive per watt with JP-8 generators (factoring in that they consume fuel).

PHASE III: PHASE III: Utilize the low cost per watt, low cut-in speed, and small total system package developed through this SBIR would greatly benefit remote or disaster relief areas in need of mobile, efficient, and reliable power. If advanced enough the resulting product could take advantage of commercial and industrial applications that were previously not feasible due to high watt per dollar costs, vertical space limitations (tall towers are needed for effective HAWT), or low average wind speeds.

REFERENCES:

[1] Vertical Axis Wind Turbine Radar Impact Assessment
http://www.quietrevolution.com/downloads/pdf/factsheets/C.017a%20assessment%20released%20by%20QinetiQ%20on%20VAWT%20radar%20Impact%20.pdf

[2] TRICON Specifications
Type I: http://www.cmci.com/Brochures/TriCon-I.pdf
Type II: http://www.cmci.com/Brochures/TriCon-II.pdf
Type III: http://www.cmci.com/Brochures/TriCon-III.pdf
Type IV: http://www.cmci.com/Brochures/TriCon-IV.pdf

[3] MIL-STD-1474D

[4] MIL-STD-810G

KEYWORDS: Wind Energy, Wind Turbines, Redeployable Wind Energy System

A12-052 TITLE: Novel Textiles for Use as Friction Buffer on Parachutes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Investigate and develop a fiber or material that is not 100% cotton and will reduce or eliminate the nylon against nylon friction and heat buildup that occurs during parachute deployment

DESCRIPTION: Nylon canopy cloth and nylon suspension lines are dragged across other nylon fabrics at very high speeds during the T11 parachute deployment. The deployment sequence takes less than 7 seconds to extract a 1670 ft2 nylon parachute from a 31 ft2 nylon pack tray. The high speed of this deployment generates heat from friction which can cause burns and damage to the nylon materials. To prevent damage caused by this friction, the canopy is folded into a 19 ft long cotton sleeve that is packed into the nylon pack tray. The sleeve acts as a protective “buffer” between layers of nylon canopy and the pack tray materials. Other examples of cotton “buffer” applications in airdrop equipment include: parachute suspension line stow loops, deployment bags, an interlayer between nylon webbing in a multi-loop extraction line, or confluence wraps to organize parachute vent lines.

The yardage of the individual cotton materials that are needed on a per parachute or per contract basis is substantial for the parachute industry, but trivial when compared with cotton used for the apparel industry. Because of this, it is often hard to procure each type of material in a timely manner, at a reasonable cost, and with consistent quality. Cotton is easily susceptible to degradation by microorganisms and is required to be fungus-proofed to prevent mold and mildew. Some of these treatments are hard to obtain because of EPA restrictions, and can further reduce the strength and durability of the cotton material.

The cotton materials in parachute equipment that have been water jumped or exposed to rain require special procedures to dry, inspect and potentially replace. In fact, military units are finding that exposure to drop zones wet from morning dew will cause cotton deployment sleeves to mold in the short time between drop zone recovery and inspection. At this time, it is undesirable to treat the cotton sleeve with a fungicide due to long term close contact with nylon canopy cloth.

In 2009, the Army published a Request for Information on the PIA-C-5646 cloth, looking for a domestic cotton supplier that could meet specification requirements; no producer came forward with interest or capability in supplying the material. Relocation of cotton fiber production to foreign countries, coupled with a domestic shift to produce longer and finer cotton fiber, makes it difficult to consistently find Berry Amendment compliant cotton fiber in adequate strength to meet material specification demands. A search of past SBIRs has yielded no investigation of this kind during the past 30 years.

Because of these issues, the Army is searching for an innovative alternative to 100% cotton material that would provide the same friction buffering and heat absorbing properties that are currently provided by cotton. Innovations in composite fibers, modified nylons, blended natural and synthetic yarns, bi-component fibers, novel weaves and nonwovens, and permanent coating are all technologies that may be considered. The ideal solution would be one material that could be used in all buffer applications, although multiple solutions will be considered.

PHASE I: This phase will focus on establishing the technical feasibility to develop materials and/or methods that can directly replace cotton as a buffer in specific parachute applications. Several methods to develop novel alternatives to the traditionally used 100% cotton webbing or cloth should be investigated for their suitability and effectiveness. The proposed material would need to prevent heat degradation and abrasion to the base nylon material during deployment to a same or better degree as current cotton, i.e., have a coefficient of friction (CoF) equal or lower than that of currently used cotton materials and the same nylon materials.. In addition to protecting the nylon base material from friction damage, the proposed material shall be of similar or lesser weight and cost as current cotton buffer material, as well as possess similar or better performance in terms of strength, flexibility, durability, sewability, chemical resistance and stability. The proposed solution shall also pose no adverse impact to current packing, deployment and recovery procedures. Examples of materials currently used as buffers in cargo and personnel parachutes include: PIA-C-5646, PIA-C-2002, MIL-W-530, Type III, Class I, 3" wide, PIA-T-5661, Type I, ¼" wide and PIA-T-5665; of particular interest for currently fielded equipment is PIA-C-5646 (cloth) and PIA-C-5665 Types II, III, and XII (webbing).

As previously noted, the proposed material will need to provide protection to the base and applied nylon materials to a degree that is as good as or better than that of the current cotton buffers upon application of a frictional force similar to that generated during parachute deployment. Therefore, bench top proof of concept demonstrations of the material performance shall be performed to establish and evaluate the level of friction protection offered by the current buffer and proposed alternatives. The friction that occurs in deployment is difficult to mimic and quantify in a controlled laboratory environment and costly to thoroughly evaluate through actual deployments. Hence, laboratory test methods will have to be developed to establish baseline and proposed friction protection performance levels. It is essential that any proposed solution including textiles that fall under the Berry Amendment would comply with all its requirements. The most effective designs, materials, manufacturing processes and test methods will be determined and proposed for Phase II efforts. A report and functioning material samples shall be delivered documenting the research and testing development supporting the effort along with a detailed description of materials, processes and associated risk for the proposed Phase II effort.

PHASE II: During Phase II, further development of the concepts derived in Phase I could be pursued with the ultimate goal to demonstrate the heat and friction protection on prototype equipment. The awardee shall develop, demonstrate, and deliver fabric and parachute prototype(s) that are in accordance with the objectives identified in Phase I as possessing the ability to protect the base nylon material and applied nylon material as well or better than traditional cotton material in the same configuration. While laboratory testing could be part of the demonstration process, the technology should also be demonstrated using simulated or actual dynamic forces equivalent to those generated when deployed from an aircraft in an airdrop environment. In addition to the delivery of fabric and equipment prototypes, a report shall be delivered documenting the research and development supporting the effort along with a detailed description and specification of the materials, designs performance and manufacturing processes.

PHASE III: Fabrics that prevent heat degradation and friction have potential commercial application in manufacturing, cleaning, automotive, etc. The offeror should aggressively pursue opportunities for the employment of the cotton alternative buffer material in these applications or other innovative uses.

REFERENCES:
1. PIA-C-5646-Cloth, Airplane

2. PIA-W-5665 Webbing, Textile, Cotton Warp

3. MIL-W-530 Webbing, Textile, Cotton, General Purpose, Natural or in Colors

4. PIA-C-2002-Cloth, Duck, Plied-Yarns, Dyed, Army Duck.

5. Parachute Recovery Design Systems Manual, Knacke

6. The Parachute Manual, Poynter

7. The Berry Amendment (BA), 41 U.S.C. § 2533a

8. ASTM D 1894 Coefficient of Friction

9. Comparative Study of Friction Coefficient in Nonwovens using Frictorq, Fabric Friction Tester, Lima M.

KEYWORDS: cotton, friction, nylon, parachute, buffer, sleeve, deployment-bag

A12-053 TITLE: Design Tool for Electronic Textile Clothing Systems

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and demonstrate a predictive software tool for designing a wearable electronic network, develop and demonstrate the associated textile materials, seaming technology, and associated fabrication hardware by creating an electronic textile-based clothing system

DESCRIPTION: A wearable transparent network is highly desired for the individual soldier and one method of achieving this capability is to integrate an electronic network into the soldier's protective clothing system. Eliminating legacy cables lowers the soldier clothing profile, and reduces weight, bulk, and snag hazards. Numerous materials and methods have been investigated and the ability to integrate conductive materials such as stranded copper wire, tinsel wire, and metallic coated synthetic fiber into various narrow fabrics, broadloom fabrics, and body conformal knits have been developed and proven. These fabric-based electronic systems known as electronic textiles have been demonstrated to support wearable networks, power and/or data bus, and wearable antennas. Devices including an electronic snap have also been developed and demonstrated to connect networks, electronic subsystems, and sensors. In addition, materials and methods have recently been developed and demonstrated that form durable conductive pathways across garment seams that transmit power and video. However while the materials and methods are available, no computer aided design tools, predictive models or other science and mathematics-based methods are available to plan, design, and construct a virtual electronic textile-based clothing system. In addition, associated fabrication hardware is needed to literally build the clothing system. The objective of this topic is to develop and demonstrate a predictive software tool for designing a wearable electronic network, develop and demonstrate the associated textile materials, seaming technology, and associated fabrication hardware by creating an electronic textile-based clothing system.

PHASE I: Establish the technical feasibility to develop a predictive software tool to be used to design the wearable electronic network and associated clothing system that takes into account design variables such as material construction, pattern geometry, and seam construction. The network shall be electromagnetic interference (EMI) shielded in accordance with MIL-STD-461. An overall specification for the software system and hardware components shall be investigated, identified, defined, and planned. Software protocols and compatibility will be investigated and discussed. A report shall be delivered documenting the research and development supporting the effort along with a detailed description of materials, processes, and associated risk for the proposed Phase II effort.

PHASE II: The contractor shall develop, demonstrate, validate, and deliver one working set of design software tools and associated hardware that performs in accordance with the goals described in Phase I. One working prototype clothing system (jacket and trouser) shall be delivered that contains an integrated electronic network that was designed and constructed using the design tools. A report shall be delivered documenting the research and development supporting the effort along with a detailed description and specifications of the software, hardware, materials, performance, and processes.

PHASE III: The software tools and associated hardware may be used to design any clothing system for specialized use that requires sensors and electronic networks. Potential applications include the development and demonstration of novel future military protective clothing systems, as well as protective clothing for fire fighting, law enforcement, first responders, urban search and rescue, and foreign military.

REFERENCES:

1. T. Wilson, J. Slade, “Development of Non-Standard Wearable Connectors for USB 2.0 Textile Cable,” U.S. Army Natick Soldier Research, Development and Engineering Center Technical Report, Natick/TR-06/011, March 2008.

2. C. Winterhalter, J. Teverovsky, P.Wilson, J. Slade, W. Horowitz, E. Tierney, V. Sharma, “Development of Electronic Textiles to Support Networks, Communications, and Medical Applications in Future U.S. Army Protective Clothing Systems,” Institute of Electrical Electronics Engineers, Transactions on Information Technology in BioMedicine, September 2005, Vol 9, No. 3. pp. 402–406.

3. C. Winterhalter, J. Teverovsky, P. Wilson, J. Slade, B. Farrell, W. Horowitz, E. Tierney, “Development of Electronic Textiles to Transport Data and Power in Future U.S. Military Protective Clothing Systems,” Journal of ASTM International, July/August 2005, Vol. 2, No.7.

4. C. Winterhalter, J. Teverovsky, W. Horowitz, V. Sharma, K. Lee, “Wearable Electro-textiles for Battlefield Awareness,” Proceedings of the 24th Army Science Conference, December, 2004.

5. “Electronics on Unconventional Substrates – Electrotextiles and Giant Area Flexible Circuits,” Materials Research Society, editors S. Shur, P. Wilson, and D. Urban, Volume 736, Symposium Proceedings Fall 2002.

KEYWORDS: Computer aided design, computer aided engineering, electronic textiles, wearable electronic network.

A12-054 TITLE: Development of Lightweight, Recyclable Low Cost, Nonwoven Cloth Duck Material

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop alternative lightweight version of woven 500 Denier Nylon Duck material with use of recyclable fibers / nonwoven materials. Demonstrate equal or better physical properties with similar hand, thickness, abrasion resistance, and hydrostatic water-proofness with consideration of limited flame-retardant (FR) without melt-dripping, mold/mildew and petroleum, Oil and Lubricant (POL) resistance.

DESCRIPTION: Mil-C- 43734 “Cloth, Duck, Nylon”, Types 4 & 5 utilize 500 Denier Textured Nylon yarns with a polyurethane backcoating to provide for a minimum hydrostatic resistance of 35 centimeters . These materials serve as a mainstay for military Equipage type end-items including Field Packs, Tactical Load Bearing Vests, Body Armor Fragmentation Protective vests, parachute bags, shelter components, ground covers and numerous other applications. Due to its’ extreme breaking, tearing strength properties, abrasion resistance and water proof characteristics it’s a highly versatile material. However, its major drawback is lack of FR. The material possesses extreme burning with total Melt-Dripping. Goal is to develop an initial 500 Denier alternative nonwoven material ranging from 4.0 – 5.0 oz / sq yard weight, per ASTM D- 3776 with minimum breaking strength of 325 lbs in warp (Machine) direction and 225 lbs minimum in filling (cross machine) direction per ASTM D- 5034, not to exceed thickness at 0.030 inches per ASTM D- 1777 and possessing less cube and bulk with consideration to reduce FR burning and melt-drip threat characteristics for Phase II. Also, achieve dynamic absorption not to exceed 20 percent per AATCC TM-70, maintain cold properties down to -40 degrees F, and offer water repellent (WR) spray rating at minimum of 90,90,80 in initial state per AATCC TM-42 . It is known that there are numerous material technologies that could possibly create such an alternative material to the 500 denier woven material.

PHASE I: Determine technical feasibility to develop alternative nonwoven material for current 500 denier duck material offering similar physical properties, hand, stiffness, hydrostatic resistance, spray rating, resistance to organic liquid, low temperature, water repellency spray rating, dynamic absorption, POL resistance and characteristics as listed above. Also material shall be dyeable / printable and launderable at minimum of 10 times while maintaining appearance, hand, WR and general properties along with possessing minimum shrinkage of 4 % and possess lower cost opportunity. Discuss potential of incorporating FR characteristics into material, technical difficulties and/or limitations to develop using recycled fibers/materials, effect of material cost comparisons (current 500 duck vs alternate FR material vs use of recyclable fibers) and potential recyclability of end-items constructed of alternate material. Prototype deliverable of base FR alternative material (s) would be expected for Government verification and testing.

PHASE II: Define manufacturing process to achieve high production rate as related to full scale production of FR product and develop prototype samples using Recyclable fibers / materials to achieve FR properties and expand properties to include potential for alternate 1000 denier Non-FR Nylon duck material. Submit minimum of 50 prototype end-items for field trial as agreed upon per Gov't direction at Award of Contract (AOC). This is necessary to determine sewabilty of alternate materials and end-item selection to reflect urgency or priority on government's part at AOC. Contractor shall confirm physical properties of three alternate materials (500 denier FR w/ new fibers, 500 denier FR with recyclable fibers and 500 denier FR with POL and Mold/Mildew resistance), laboratory abrasion determinations, launderability and large scale manufacturability of materials.

PHASE III: Initial use for this technology will be to outfit the military users with a lightweight equipage type material offering increased FR protection vs current nylon duck cloth. Potential commercialization of Phase II results would be welcome and used for private sector applications. Other uses may include basis for FR composites or molding applications. All Phase III efforts shall follow statutory criteria for Phase III activities and/or military endorsements for further funding.

REFERENCES:
1. http://www.techtextilna.com/3rdp_files/ttna_news_1208/ttna_symposium.html (Techtextil Symposium briefing).

2. MIL-C-43734 " Cloth, Duck, Textured Nylon" specification, see:
https://assist.daps.dla.mil/quicksearch/doc_num_help.cfm for direct access to Defense and Federal specifications and standards available in the official DoD repository.

3. http://www.baesystems.com/Sites/NationalGuard/IndividualEquipment/MOLLE/index.htm (Modular Lightweight Load Carrying Equipment)

4. http://www.indiantextilejournal.com/articles/FAdetails.asp?id=535 (future nonwoven applications).

KEYWORDS: Nylon, Duck, Flame Retardant (FR), polyurethane, denier, equipage, nonwoven.

A12-055 TITLE: Non-Toxic, Non-Incendiary Obscurant Smoke for Ammunition and Munitions

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: Currently high yield smoke compositions such as White Phosphorous (WP), Red Phosphorous (RP) and Hexachloroethane (HC), while high performance obscurants, are extremely toxic with incendiary characteristics. Non-toxic and non-incendiary solutions providing the same high performance do not currently exist. The objective of this topic is to develop a non-toxic and non-incendiary chemical material solution that will meet or exceed the current performance characteristic for obscuration screening through cannon fired artillery and hand emplaced munitions. This material solution does not exist and requires an innovative solution. This effect will address Army Technical Area 1 or 10.

DESCRIPTION: This topic is intended to find a chemical solution to minimize or eliminate the toxic and incendiary effects of the reactions from smoke compositions or obscurants while maintaining or increasing obscurant performance with the same or improved high performance obscurant properties (Extinction Coefficient > 3.0 m^2/g, Yield Factor > 3@50% r h). Current potential solutions such as terepthallic acid (TA) and Cinnamic Acid (CA) are lower in toxicity and exhibit a lower incendiary hazard, but do not meet the current obscurant performance requirements. Compositions that have higher extinction coefficient perform better as an obscurant or substance, absorbing light and blocking views. The obscurant must provide screening through visible and infrared wavelengths but ideally it is desired that the obscurant provides screening for multiple wavelengths including microwave and millimeter-wave. Logistically the obscurant compositions must provide an acceptable tradeoff between the quantities of rounds needed to obscure vision and what can be reasonably transported. The current obscurants provide suitable screening through one wavelength or another but contact with them while reacting can cause severe injuries or even death. The effects on people and animals are known to cause burning deep into tissue and prolonged exposed by inhalation or ingestion can cause fatal reactions. PEO Ammo anticipates that this will become an environmental and humanitarian policy issue in the very near future and is proactively attempting to identify new obscurant chemistries to provide human and environmentally friendly multi-spectral, persistent and cannon fired solutions. Also, the toxic and incendiary nature of current obscurants limits the ability of the user to train with the items. The obscurant composition must be able to survive the High-G load environments of Cannon Artillery. M483/M863 Carriers will be the projectiles used for integration to use the current stockpile of munitions. It is also desired that the same or a variant of the eventual solution be used in hand emplaced grenades and other munitions as well. Due to the nature of Cannon Artillery, these types of munitions are fired into high populated and urban areas; therefore, elimination of the incendiary and toxic effects is increasingly important in order to reduce collateral damage. Consideration should also be given to similar screening smoke fills for 81mm and 120mm mortar applications. Current efforts in the tech base are investigating pyrotechnic systems to produce metal chlorides and phosphoric acid materials to produce a high yield smoke, but have yet to deliver a chemical material solution. Other efforts include maximizing particle extinction coefficients (Army Tech Base and SERDP program) and other pyrotechnics systems. This is a difficult technology problem to find replacements for WP/RP or HC. A suitable solution will be implemented in the ammunition products as product improvements.

PHASE I: Research and Develop new chemical compositions that will provide non-toxic and non-incendiary effect for smoke screening. The result of Phase I will be a technical analysis of candidates proposed chemical solutions showing which solutions have the potential to meet program requirements.

PHASE II: Based on the results of Phase I, prototype compositions of potential solutions will be developed and validated through lab testing and any other testing deemed necessary. The compositions will then go through a down select for the best solution to provide non-toxic and non-incendiary result while demonstrating improved or equal results as the current smoke screening performances. Through subcomponent testing, the functionality and reaction will be validated. An Environmental Assessment will be conducted on the material to validate its incendiary and toxicity effects on the environment

PHASE III: Once a final obscurant solution has been selected, it will be integrated into the M483 or the M864 carriers to replace current obscurant solutions. The performance will then be characterized against current obscurant solutions to baseline the performance. A final demonstration will be concluded to show the functioning of the obscurant in a realistic environment and that all subcomponents survive the gun launch environment. Practical applications also extend into the commercial/non-military realm as a tool for crowd/riot control, screening confined areas, entertainment, etc.

REFERENCES:
1. Butler, Brian A. “Smoke and Obscurant Operations in a Joint Environment.” AIR COMMAND AND STAFF COLL MAXWELL AFB AL, 01 Aprl 1998.

2. Hardaway, G. M. “Visualization of Battlefield Obscurants.” ARMY TOPOGRAPHIC ENGINEERING CENTER FORT BELVOIR VA, 01 Oct. 1991.

3. Shinn, Joseph H., Laurel Sharmer, and Michael Novo. “Smoke and Obscurants: A Guidebook of Environmental Assessment. Volume 2. A Sample Environmental Assessment.” LAWRENCE LIVERMORE NATIONAL LAB CA, 04 Sept. 1987.

4. Welford, Ian Poulson, Grahame W. Collins, and Peter J. Hutchinson. “Chemical Composition and Toxicity Assessment of Pyrotechnic Obscurant.” DEFENCE EVALUATION AND RESEARCH AGENCY KENT, 01 Jan. 1996.

5. Bickford, Larry. “Smoke and Obscuration Data.” ARDEC. Picatinny Arsenal, NJ. 21 October 2009.

6. Olgac, Vedat. “XM2002, and XM2004 Smoke Projectile Mass Extinction Coefficient: Results.” PM CAS. Picatinny Arsenal, NJ. 2 November 2005.

KEYWORDS: Ammunition, Non-Toxic, Non-Incendiary, Multi-Spectral, Artillery, Smoke, Obscurant

A12-056 TITLE: Innovative Solutions for Propellant Temperature Sensing for Future Munitions

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: Knowing the exact propellant temperature of large caliber ammunition can greatly enhance the accuracy, and thereby the terminal effects. The objective of this topic is to research and develop innovative solutions that will measure actual propellant temperature and report it in real time to the appropriate fire control system during the weapon aiming and firing process. United States Patent 5700088, “Ammunition propellant temperature measuring assembly”, describes an assembly that measures ammunition propellant temperature by measuring the surface temperature of the ammunition and extrapolating to determine the internal temperature of the propellant. This topic will develop technologies to directly measure the internal propellant temperature of the ammunition.

DESCRIPTION: There are five requirements for achieving accurate first-round fire for effect. These requirements are: 1) accurate target location and size, 2) firing unit location, 3) weapon and ammunition information (including propellant temperature), 4) meteorological information, and 5) computational procedures. A significant source of error is the uncertainty associated with the muzzle velocity of the round when it leaves the weapon. The muzzle velocity error is a function of the variability of the propulsion system components and the temperature of the propellant when fired. If these requirements are met, the firing unit will be able to deliver accurate and timely fires in support of the ground-gaining arms. If the requirements for accurate predicted fire cannot be met completely, the firing unit maybe required to use adjust-fire missions to engage targets. Adjust-fire missions can result in less effect on the target, increased ammunition expenditure, and greater possibility that the firing unit will be detected by hostile assets. Current systems employing Large Caliber Ammunition do not accurately measure the temperature of the propellant, the most widely used method is to use ambient air temperature and manually calculate the adjustment or manually input the temperature into a fire control computer. Sensing the Propellant Temperature and transmitting the data directly to a fire control computer can improve velocity predictions and reduce user workload for improved accuracy and improved performance of future ammunition. For 155mm artillery, the one of the largest contribution to accuracy errors comes from errors in muzzle velocity. For MACS 232 zone 5, a 10 degree difference in temperature results in a 4 m/s error in muzzle velocity. With a time of flight of 100 seconds, this error could result in a 400m error on the ground. The standard deviation in Muzzle Velocity is reduced by 50% by identifying the specific lot number of the ammunition being fired and using the Muzzle Velocity for that specific lot to compute a more accurate ballistic solution. Using more accurate propellant temperature would also further reduce the uncertainty of muzzle velocity.

PHASE I: Phase I objectives are to research candidate technologies that can meet program requirements, documented in a technical report that will identify candidate technologies and their probability of meeting requirements based on technical analysis. A laboratory prototype will be delivered at the end of Phase I.

PHASE II: Phase II objectives are 1) prototype development of a system capable of measuring propellant temperature with the required accuracy and within the required timing to representative fire control systems 2) Analysis of the prototype in a simulated operational environment of ammunition storage, loading and firing. 3) perform demonstration of the system at ARDEC site

PHASE III: Phase III will include integration of the successful Phase II technology into the target ammunition systems and tested in an operational environment in preparation of transition to production.

REFERENCES:

1. Trohanowsky, Raymond S., “120mm Mortar System Accuracy Analysis”, US ARMY RDECOM-ARMAMENTS RESEARCH, DEVELOPMENT & ENGINEERING CENTER, May 17, 2005

2. US Army Field Manual FM 6-40, “Tactics, Techniques and Procedures for Field Artillery Manual Cannon Gunnery, April 23, 1996

3. United States Patent 5700088, “Ammunition propellant temperature measuring assembly”, December 23, 1997

4. Diamond, P., “Electro Thermal Chemical Gun Technology Study (JSR-98-600)”, March 1999

KEYWORDS: Ammunition, Accuracy, Propellant, Temperature Sensor, Fire Control, Tank, Artillery, Mortar

A12-057 TITLE: Launch-able Tagline and Remote Anchor System

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

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

OBJECTIVE: An anchor system that when launched across a river or upstream can proof-load an anchor with tagline running back to the launch site.

DESCRIPTION: Develop a system that when launched (catapulted or submerged) to a remote location can set and proof load an anchor point for a tethered cable.
1. Develop a system that could be launched across a gap, secure a mechanical anchor and then proof load it to verify proper setting.
a. The system would have to be durable enough to sustain a catapult or propulsion launch and resulting impact after being launched across a 50-meter wet gap onto concrete or equivalent packed soil.
b. After landing, the system would have to orient itself on the far bank, penetrate the surface, and reliably secure the anchor in under 15 minutes.

2. This system shall be capable of being submerged in water and perform underwater anchorage in riverbeds.

3. This system shall be capable of being launched onto rooftops and cliffs 50 feet above the launch position.

4. This system would have to supply its own power or connect to a power source available at the launch point.

5. This system would be either remote controlled or automated and provide indication to the operator that the anchor is set and ready for use.

6. This system would connect a cable suitable for moving a minimum of a 900 lbs object horizontally along the cable to the distant 50 meter anchor position.

7. The system shall include all materials that necessarily leave the near shore launch site to span the gap - a tethered cable, anchor, mechanism for setting the anchor, and power supply or power interface. The launch mechanism used to send the system to the remote site is not necessarily part of this system. This system would be transported by HMMWV and moved to its launch position by two soldiers. The components of the system that must be launched is approximately 80 lbs and 1 cubic yard, and would be transported by HMMWV then moved to the launch area by two soldiers. Target cost for mass production system (QTY 10,000) is under $1000.

- Many styles of commercial anchor systems are available; such as Manta Ray earth anchors, pre-drill and drive into place concrete anchor systems, and Powder Actuated Tools like Remington’s 496. Each can be used to set and proof

load a mechanical anchor in situations when an operator has access to the site and power for the tools. To accomplish this task at other locations, where the inability or reluctance to put the operator on a remote site, is desired.
- This capability lends itself to many military and disaster relief uses.
- Semi-permanent tactical bridging operations often require anchor points to be established to maintain a bridge position. When sustaining float bridges for river crossing operations, an ideal anchor position is directly upstream from the center of the bridge, and out of the way of floating debris. With the ability to remotely set a proof-loaded anchor in the water up-river, an operator could install the system and sustain floating bridge operations using fewer boats to hold the bridge from floating downstream, and eliminate the need for 100 lbs. kedge anchors and divers (often unavailable) to set riverbed anchors.
- Troops also need to cross gaps where there is no bridge or means to cross on foot. Rapid zip line style crossings on the tethered cable could be made to any location that could only be reached by launching the remote anchor system.
- Supplies, like construction materials, could be moved precisely to the anchor point after threading tubular objects with the free end of a tethered cable. Since the anchor is proof-loaded before use, a solid base for constructing upon the remote site anchor point is established.
- Current bridge launch systems are vehicle mounted systems requiring substantial weight (often limiting the mobility of the host vehicle), require large flat launch area access, and cantilever bridges over dry gaps. This launch technique requires substantial counterbalance to prevent objects from falling into the gap. Properly anchored parallel cables of sufficient strength could simply support objects as they are moved across a gap, and remain in place to serve as added reinforcement for a bridge built upon the suspended cables. An emplaced anchor and cable could serve to launch a heavier cable and anchor system onto the far shore; eventually building up to the desired capacity at the far anchor site and over the gap.

To support precise aerial-to-ground delivery from a helicopter, the system could be used to eliminate the need to land or hover over a delivery target for aerial delivery of supplies, assemblies, and construction material.

PHASE I: The phase I effort will identify feasible solutions, existing technology for integration, and technology gaps / risk to achieve the objective. A proof-of-concept experiment will demonstration viability of phase II system's highest risk attributes. This investigation, trade-off study, and proof-of-concept will culminate in a recommended Phase II prototype build and demonstration program to verify the system readiness for tactical deployment.

PHASE II: Will build and verify a prototype systems readiness for use in a relevant environment. Testing in a wet operation and dry gap crossing environment will demonstrate the prototypes viability for a production qualification test.

PHASE III: A manufacturing plan will be developed around the production of a Production Qualification Test system build. Marketing will consist of product demonstrations and advertising using videos of product and recorded demonstrations. A universal anchoring kit for PEO-CS&CSS LAGCC Type 1 footbridge procurement, and float bridge sustainment operations. Commercialized technology could be used for boat anchors, providing ground holds to provide counterbalance to light-weight vehicles, when used with bearing plates it could provide soil stabilization, install reinforcements for sea walls, install safety lines for rock climbers, build piers/docks, used to stabilize a suspect structure after earthquake, or provide rescuers access to high rise buildings from adjacent buildings. Used to erect and reinforce towers. Stabilize structures in a post-disaster recovery operation.

REFERENCES:
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https://www.fbo.gov/index?s=opportunity&mode=form&id=e776ed6e86028f9e4694535bd80cd293&tab=core&_cview=1

2.
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KEYWORDS: mechanical anchor, remote, tagline, bridge, launch, tether, ground penetrating, zip line,

A12-058 TITLE: <u>Fatty Acid Methyl Ester (FAME) Portable Detection Device for Fuel Contamination (JP-8, Jet, and Diesel)</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop and demonstrate an analyzer for detecting low levels of FAME in JP-8, Jet and Diesel fuel, to be used in a mobile laboratory environment. Satisfies RDECOM Technology Area of Interest - GSN-486; Fuels Contaminate Detection.

DESCRIPTION: Alternative fuels and alternative energy have become a focal point for government and DoD programs. With the recent mandates to use alternative fuels, refineries have been forced to blend biofuels (including FAME biodiesel) into conventional fuels; which are then introduced into the existing distribution infrastructure (ie pipelines, trucks, rail cars). In the United States, ASTM D 975, Standard Specification for Diesel Fuel Oils, now allows up to 5% FAME Biodiesel to be blended into the conventional diesel fuel. Additionally, the European Union allows up to 7% FAME biodiesel into their conventional diesel fuel per EN 590, Automotive Fuels - Diesel - Requirements and Test methods. The threat of FAME contamination into jet fuels has become a problem as pipeline trail back has been confirmed. The Army must continue to improve and optimize its fuel management to meet mission requirements. FAME contamination in jet fuel impacts the thermal stability and freezing point properties of the jet fuel which could lead to engine operability problems or potential engine flame out. The need for analysis of fuels in a mobile environment requires innovative technologies with the capability to test jet fuel for FAME contamination so the determination can be made whether the fuel can be used. Additionally, the analysis of fuels for ground use (diesel & JP-8) to confirm the FAME content is also desirable. Ground fuels used in military applications is not as readily consumed and may be stored for long periods of time. Ground fuels are used across the entire spectrum of environmental conditions and FAME contaminated fuels may have operability problems at low temperatures. Current commercially available technologies include Gas Chromatography - Mass Spectrometry (GC-MS) and Fourier Transform Infrared Spectroscopy (FTIR) techniques to analyze FAME content. However, the instruments available do not currently meet the needs of the Army's mobile laboratory. If an instrument can be designed to meet the needs of the Army's mobile laboratory environment, the instrument would have the potential to be integrated into the Petroleum Quality Analysis System - Enhanced (PQAS-E). The PQAS-E mission is to perform fuel quality analysis on fuels prior to use, especially after being stored. The PQAS-E would ensure fuels in the battlespace met operational requirements. The commercial aviation fuel sector would also benefit from small mobile equipment for testing FAME contamination at airports.

PHASE I: Proof of concept laboratory experiments to demonstrate the technology potential to transition to a breadboard instrument or hand-held device that analyzes jet and diesel fuel for the presence of FAME at a minimum detection limit of 100ppm to 7%. Finalize a conceptual design for developing and protoyping a material system that is suitable for use in a mobile laboratory environment. Considerations for the Army's mobile laboratory application include the following: 10mL maximum sample size, analysis time not greater than 20 minutes, no dilution or sample preparation required, no computer interface, analysis of any type of base stock FAME, no bottled gases, no glass containers, no (preferred) to limited calibration requirements, ability to operate over an extended range of temperatures, resistant to shock and vibration, and a desired footprint of not greater than 12" wide by 24" deep.

PHASE II: Based on best design parameters discovered in Phase I, build and demonstrate a prototype analyzer (benchtop or hand-held) that can be tested in a relevant environment. The system shall maintain the considerations listed in Phase 1.

PHASE III: PM PAWS can integrate the technology developed under this SBIR into the Petroleum Quality Analysis System - Enhanced or the Aviation Fuel Contamination Test Kit (AFCTK) to ensure the fuel quality meets mission requirements. Fuel quality facilities at commercial airports may also benefit from the technology developed under this SBIR.

REFERENCES:
1. ASTM D 1655, Standard Test Method for Aviation Turbine Fuels

2. Joint Inspection Group Operations Bulletin No 37, October 2010. High FAME Content Protocol

3. Baljet, Michel. FAME/Airport Aviation Fuelling. International Airport Review, Issue 6, 11 December 2009.

KEYWORDS: fatty acid methyl ester, FAME, biodiesel, aviation turbine fuel, jet fuel, mobile laboratory

A12-059 TITLE: Occupant Sensor Suite for Blast Events

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Currently no method exists to record occupant data from combat vehicles during blast events, desired end product is a universal occupant sensor suite to record blast data in any vehicle.

DESCRIPTION: The Tank Automotive Research Development and Engineering Center's (TARDEC) survivability group has identified the lack of accurate battlefield data from blast events as a significant gap in the design of occupant protection systems. By accurately monitoring blast events on the battlefield, research can focus on counteracting threats as they emerge. In contrast, our current method entails performing blast experiments at test centers to simulate different scenarios that may or may not accurately represent actual threats.

The Army does not have an accurate model of an occupant during a blast event for threats encountered on the battlefield. Data acquired from the Occupant Sensor Suite will improve modeling predictions of occupant sustained blast events. This is turn will lead to the development of dynamic models that can establish key design parameters throughout all occupant protection design activity.

PHASE I: Phase I consists of an investigation of the aspects (forces, displacements, etc) sustained by the occupant during a blast event. The most critical aspects, considered system inputs, will be identified. The inputs shall provide sufficient data to accurately model and analyze the human response for designing future occupant protection systems. Formulas and calculations shall be documented. The following aspects shall be consider in sensor selection: High fidelity (Able to record data at required sample rate), Max Life (Up to 20 years), Connectivity to Army's Vehicle Data Recorder, Operating Conditions/Temperatures, Calibrationless, Low cost (Target: $100 per seat, Acceptable: <$500, Minimum Requirement : <$1000). Study shall detail locations of sensors and plan for mass integration into Army Platforms. Recommended platform is the MRAP, but any currently fielded seat from any Army Combat Vehicle can be referenced with Government approval.

PHASE II: A fully functional seat demonstrator is expected upon completion of Phase II contract.
SEAT: Contractor must select a seat that meets Government POC's approval. Government approval is needed to ensure seat is representative of occupant seats found throughout the Army.
REPORT: Report shall include the following:
(1) SENSORS: Sensors used with specifications, purpose/output of sensors, general locations of sensors (to address varying types of seats and vehicles).
(2) DATA ANALYSIS: Detailed information regarding filtering of data and/or post processing methods for data analysis. Report shall include how to incorporate the data acquired into useful data for modeling or design parameters. This includes formulas that were needed for conversion into English Units, adjusting accelerometer axis on angled surfaces, etc. Include computer code used for processing.
(3) TESTING VERIFICATION: Report shall provide details on test setup, operation, and results. Verification of the accuracy and reasonability of test results must be documented. A Government Subject Matter Expert (SME) can verify reasonability of test results, contact your POC for a suitable SME. Accuracy can be proved by calibration certificates and/or calibration test results. If needed, Selfridge Air National Guard Base located in Southeast Michigan has a drop tower that simulates blast events. Please contact the Government POC regarding scheduling and costs associated with testing.

ADDITIONAL INFORMATION: If during the Phase II work period an SME finds the sensor suite or the data insufficient, such as not providing useful data or information, the contractor has the ability to readdress the issue and retest within the Phase II time frame. The Occupant Sensor Suite shall be integrated into an actual vehicle seat and connected to the Vehicle Blast Data Recorder. Contact the POC for more information regarding the Vehicle Blast Data Recorder. Overall results of Phase II are the effective communications with the Vehicle Blast Data Recorder, seat integration, and the usefulness of the results. If no Vehicle Blast Data Recorder is available, contractor may develop his own Data Collection System that meets the requirements of the Vehicle Blast Data Recorder.

PHASE III: Occupant Sensor Suite can be implemented on all seat positions on all ground combat vehicles (US Army, Marines, etc.) to evaluate emerging occupant threats. The Sensor Suite will serve as an additional and critical input to the Army led Vehicle Blast Data Recorder. Technology can be integrated into other unique systems as a method to evaluate ride quality. Technology can be inserted into the automotive industry, racing industry, and aviation to evaluate their particular occupant aspects.

REFERENCES:
1. TARDEC Info Paper on Blast Events:
http://204.255.139.206/Tardec/Documents/AM0709_Blast_Simulation_Software.pdf

2. TARDEC Info Paper on Blast Mitigating Seats: http://www.ndcee.ctc.com/task_descriptions/N_0730.pdf

3. Modeling Mine Blast Effects: http://www.tardec.info/GVSETNews/article.cfm?iID=0703&aid=09

KEYWORDS: Mine, IED, Blast, seat, sensors, black box, occupant, protection, safety, sensor, accelerometers, Data, Recorder

A12-060 TITLE: Standoff Counter Human Deception Detection Device

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: This program will develop a standoff device which efficiently assesses psychophysiological characteristics to covertly determine truthfulness/creditability of subjects undergoing questioning. The device should be handheld, ruggedized, functional in varied environments, and accurate.

DESCRIPTION: The US Army lacks a capability to efficiently distinguish between persons-of-interest and regular citizens, based on source interrogatory responses acquired during screening operations. Current deception detection systems are overt, bulky, intrusive and relatively slow. Accordingly, the US Army has a need to leverage state of the art technologies which may provide Counter Intelligence (CI) and Human Intelligence (HUMINT) teams with the capability to determine source truthfulness/creditability during (i) screening operations, (ii) source vetting and (iii) in assessing deception during interrogation and questioning operations. Counter Human Deception Detection Device tools will support the triage of subjects, witnesses and sources and more accurately cue full exploitation and investigative support activities. The ideal Counter Human Deception Detection Device will augment sound questioning techniques and investigative methodologies by providing an additional tool to supplement the skills of CI and HUMINT collectors. The objective technology will be leveraged to provide CI and HUMINT teams with the capability to assess human deception without physical contact between the device and the subject-of-interest.

PHASE I: Phase I of this effort will focus on device concept development with strong consideration of the device's standoff requirement and the psychophysiological characteristic or combination of characteristics that can be exploited to determine possible deception. The Counter Human Deception Detection Device design should represent a compact, ideally handheld, form factor capable of attaining a 2-meter (minimum) standoff distance. In addition, data processing algorithmic approaches should be considered which may be combined with the Counter Human Deception Detection Device concept to realize the final system. The Phase I feasibility study should also address dissemination of the data to local computer networks using either Wireless Fidelity (Wi-Fi) or Worldwide Interoperability for Microwave Access (WiMAX). The Phase I deliverable will be a final report which documents all the findings from the past six months.

PHASE II: Based on the results from Phase I, an initial prototype device will be developed and demonstrated in a laboratory environment. The technical merit of the proposed solution will be assessed in a laboratory environment from a range of at least 2 meters, based on its ability to (i) detect a person-of-interest, (ii) collect psychophysiological characteristic(s) relevant data from the person-of-interest, (iii) analyze the collected data, and (iv) report the subject's deception percentage on a handheld device or similarly-sized platform. The Counter Human Deception Detection Device will be authenticated against credibility validation standards established by the Department of Defense (DoD) and the National Center for Credibility Assessment. The final embodiment of the device (1) should be ruggedized; (2) have a handheld form factor or similar; (3) should be functional in both controlled (i.e., office) and tactically-relevant environments; and (4) provide real-time, automated deception detection with at least 90% accuracy in estimating a subject-of-interest's truthfulness.

PHASE III: During Phase III of this effort, the final embodiment of the standoff Counter Human Deception Detection Device will be fabricated. This final device embodiment (1) should be ruggedized; (2) have a handheld form factor; (3) should be functional in both controlled (i.e., office) and tactically-relevant environments; and (4) provide real-time, automated deception detection with at least 90% accuracy in estimating a subject-of-interest's truthfulness. At the end of this phase, three ruggedized standoff Counter Human Deception Detection System prototypes with the appropriate documentation will be delivered to Product Director Counter Intelligence Human Intelligence Automated Reporting Collection System (PD CHARCS) for validation of the system's performance against existing credibility assessment standards under tactically-relevant conditions at the National Center for Credibility Assessment. PD CHARCS is a clear Phase III transition partner along with the Department of Homeland Security (DHS) and the Federal Bureau of Investigation (FBI).

REFERENCES:
1. Burgoon, J. K.; Nunamaker, J. F. Toward Computer-Aided Support for the Detection of Deception-Volume 3. Group Decis. Negot. 2010, 19, 323 - 325.

2. Martens, R.; Allen, J. J. B. The role of psychophysiology in forensic assessments: Deception detection, ERPs, and virtual reality mock crime scenarios. Psychophysiology 2008, 45, 286 - 298.

3. Ambach, W.; Bursch, S.; Stark, R.; Vaitl, D. A Concealed Information Test with multimodal measurement. Int. J. Psychophysiol. 2010, 75, 258 - 267.

4. Nunamaker, Jay F. "Deception Detection Techniques for Rapid Screening." The DHS Science Conference – Fifth Annual University Network Summit. Ed. Christopher B.R. Diller. 2009. University of Arizona, National Center for Border Security and Immigration.
https://www.orau.gov/dhssummit/2009/presentations/March17/Panel3/Nunamaker_Mar17.pdf

KEYWORDS: Counter Intelligence, Human Intelligence, Deception Detection, Psychophysiology, Biometric

A12-061 TITLE: Secure GPS Sensor Platform (GPS-SP) for the Handheld Computing Environment

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: The objective of this project is to develop and demonstrate advanced connectivity and control technologies to enable a miniature GPS receiver to provide Selective-Availability Anti-Spoofing Module (SAASM) based Global Positioning System (GPS) capability to a Handheld device (i.e. commercial Smartphone) using an expandable sensor platform.

DESCRIPTION: The Smartphone has emerged as the single most-promising platform in the Army's product development pipeline – teams across the Army and industry have been developing and testing applications at a rapid pace. These Smartphone applications cover everything from Situational Awareness to controlling radios from your wrist. Commercial Smartphone users are familiar with using the GPS on their phone; however most do not realize that this commercial GPS cannot be reliably used in military situations. Commercial Smartphones use SPS (Standard Positioning Service), whereas military GPS devices use PPS (Precise Positioning Service) – and at first glance most non-military users think the major difference is precision, which is not the issue of concern. SPS is almost as precise as PPS, and in most cases the differences are negligible. SPS GPS receivers can be tricked by false GPS signals, also known as spoofing - the user will never even know it. SPS GPS receivers are also very easily jammed, essentially rendering them inoperable. Both of these scenarios, in a military situation, can result in mission failure and fratricide. This is why the use of SPS GPS receivers in combat operations, and combat support operations, is prohibited by the Department of Defense (DOD) policy.

PPS GPS receivers, which are based on SAASM (Selective Availability Anti-Spoofing Module) technology, are resistant to jamming and are capable of detecting spoofing. SAASM user equipment processes both Y-Code and C/A Code signals and contains special security functions unique to the military GPS. However this capability has not been developed for Smartphones, as this is a military-only capability and is cost-prohibitive in the competitive commercial Smartphone market. A major technical challenge is to develop an open-architecture connectivity solution to commercial Smartphones – connectivity could be physical or wireless. Other technical hurdles include delivering a light-weight low-cost solution in a small form factor and with an adequate power management scheme to support the core SAASM capability and the expanded sensor payloads.

This initiative should develop, demonstrate, and field an affordable, reliable, and highly capable military GPS Sensor Platform for the Handheld CE. The platform shall affix to the Soldier in a non-obtrusive manner, be lightweight and slim, have a dedicated power source, and allow convenient access to both the platform and CE human interfaces. The solution should include advanced software that resides on the CE to demonstrate interface with the GPS device. The software will demonstrate the basic capabilities of the GPS platform, as well as facilitate access to PPS GPS from other applications on the CE. The solution shall not require any hardware modifications to the CE. The connectivity method shall be developed using an open architecture, with a focus on interoperability across a wide variety of commercial Smartphones. The connectivity method shall be one that provides a secure, isolated, anti-tamper, reliable connection.

PHASE I: The Phase I deliverable will be a feasibility study documenting the past six months. The feasibility should include identifying and analyzing viable technologies for interfacing the GPS-SP to the Handheld CE. A tradeoff analysis should be conducted and a target technology selected. The small business should design an open-architecture interface that increases control and data requirements found in the Interface Control Document ICD-GPS-1534, and fits with standard design interfaces employed in commercial Smartphone's and define the software user interface that will reside on the Handheld CE.

PHASE II: Develop an initial prototype of the technology and demonstrate in a laboratory environment the technical merit of the proposed solution for the GPS-SP; successfully collect information for analysis. Develop a plan which shall include detail for the development, demonstration, maturation, and validation and verification (V+V) of these capabilities which will assist in PH III transition, including those associated with expanding the platform to accept other sensors. The small business will deliver a prototype based on the lessons learned and work performed in PH I and PH II.

PHASE III: Develop and implement a technology transition plan with Product Director Global Positioning System (PD GPS). The transition plan should include further technology maturation to include but not limited to integrating a data access port to enable the GPS-SP to output data to other systems. Finalize the GPS-SP hardware and Handheld CE software environment, and conduct qualification testing of the basic system and expanded platforms. This technology is applicable to the US ARMY and other Federal Agencies that need secure, portable, Smartphone GPS.

REFERENCES:
1. Assistant Secretary of Defense, Command Control Communications and Intelligence (ASD/C3I) Memorandum for all Service Acquisition Executives, dated August 23, 2000

2. CJCSI 6130.01D, 2007 Master Positioning, Navigation & Timing Plan, dated 13 April 2007

3. Global Positioning System, Signals, Measurement, and Performance, 2nd Edition, Misra and Enge, dated 2006

4. ICD-GPS-153D, GPS User Equipment Interface Specification for the GPS Standard Serial Interface Protocol (GSSIP), dated 23 July 2007

5. SAC Handbook Rev G, uploaded in SITIS 1/6/12.

6. CZU 09 071, uploaded in SITIS 1/6/12.

7. GPU 09 071, uploaded in SITIS 1/6/12.

KEYWORDS: Global Positioning System (GPS), Selective-Availability Anti-Spoofing Module (SAASM), Open Architecure, Smartphone, Sensor Platform, Positioning Navigation and Timing (PNT)

A12-062 TITLE: Innovative Rugged High Power RF Sources for Compact RF Warheads

TECHNOLOGY AREAS: Sensors, Electronics, 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 a launch hardened radio frequency (RF) source to form a self contained RF module that could be inserted into either the Guided Multiple Launch Rocket System (GMLRS) or the Army Tactical Army Tactical Missile System (ATACMS) missile platform.

DESCRIPTION: The primary objective of this effort is to develop a robust RF source module that can be inserted into a missile flight body and survive launch forces. The unit should be self contained and be capable of operation with no connection to on board power systems or controls.

The modules should be of size and volume to fit within either the GMLRS or ATACMS payload bay and be totally self-contained. The desired payload specifications are:
1. Total weight <200 lbs including power supply
2. A diameter less than 7.5”
3. A length less than 3’

The RF source developed under this research should operate at a frequency of either 915 MHz or 1.3 GHz and produce a minimum of 10 RF cycles. Explosively driven or non-explosively driven RF sources will be considered. For the non-explosive sources, the RF source should be able to operate for a minimum of 10 seconds with a pulse repetition rate of 1 kHz. The source should generate a nominal electric field of 50,000 volts per meter (V/m) normalized to 1 meter. There is no preference as to the antenna pattern, gain, or beam width. If an explosively powered RF source is proposed, it should be able to produce 10 bursts of 10 RF cycles.

PHASE I: Investigate methods for incorporating the RF source and power supply within the supporting RF technology into the selected missile platform. This should include a trade study with predictions as to size and volume of the proposed RF modules and a basic demonstration of the source technology. The source should be designed with shock hardening in mind with plans for the final embodiment to be hardened for missile launch.

PHASE II: Develop and demonstrate a standalone module and demonstrate free field RF transmission within a laboratory environment. The device should be capable of producing a frequency of 915 MHz or 1.3 GHz with a minimum of pulse length of 10 RF cycles for a non-explosively powered source. The non-explosive source should be able to operate for a minimum of 10 seconds with a pulse repetition rate of 1 kHz. For the explosively powered RF source, it should be able to produce 10 bursts of 10 RF cycles. Either device should generate a nominal electric field of 50,000 V/m normalized to 1 meter.

PHASE III: The final embodiment of the module developed in Phase II would be a flight hardened, drop-in device, which would be test launched on either a GMLRS or other in inventory government furnished missile. At this phase of development, which would result in a TRL level 5 device, demonstrations of effectiveness would be sought and demonstrations of fly ability of the source would be performed.

REFERENCES:
[1] R.J. Barker and E. Schamiloglu, Eds., High Power, Microwave Sources and Technologies, New York: IEEE, Press/J. Wiley & Sons, 2001.

[2] E. Schamiloglu and R.J. Barker, Eds., Proceedings of the IEEE Special Issue on Pulsed Power and its Applications (to appear July 2004).

[3] P.D. Smith and S.R. Cloude, Eds., Ultra-Wideband, Short-Pulse Electromagnetics 5, New York: Kluwer Academic/Plenum Publishers, 2002.

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[5] D.V. Giri and F.M. Tesche, "Classification of intentional electromagnetic interference (IEMI)," IEEE Trans. EMC (to appear 2004).

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[9] A.V. Gaponov-Grekhov and V.L. Granatstein, Eds., Applications of High-Power Microwaves, Norwood, MA: Artech House, 1994.

[10] http://www.de.afrl.af.mil/factsheets/activedenial.html

[11] http://www.de.afrl.af.mil/Factsheets/HPM.html

KEYWORDS: High Power Microwave, High Voltage Switching, RF Source, Explosively Powered

A12-063 TITLE: Autonomous Trackless Vehicle Target

TECHNOLOGY AREAS: Ground/Sea Vehicles, Human Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Design and prototype an inexpensive trackless vehicle moving target that can be utilized on unimproved terrain, and that is capable of autonomous behaviors based on training doctrine, skills, readiness and style of learning to enhance realism and feedback for the trainee.

DESCRIPTION: An autonomous trackless vehicle target technology would support the creation of a high fidelity immersive capability within the live training domain. The technology would provide an accurate and realistic portrayal of vehicle base threats during live fire training events, such as escalation of force or live fire convoy training. The technology focus on adaptive vehicular behavior to scale training events that take into account the dynamics of individual differences in learning style, experience, knowledge, skills, and readiness in a small unit environment. The technology will provide accurate and realistic feedback through movements, representation, and engagement behavior (act and react based on trainee actions). The technology will support of training and individual differences, after action reporting, high fidelity immersive training, and adaptive learning.

Based on user feedback, rail based moving targets provide an unrealistic and limited training experience to soldiers, especially with respect to urban operations and escalation of force environments. The primary issues stem from their predictability and linear constraint of motion of the targets, with soldiers being able to reliable predict movement and future position of the targets. Additionally, for safety reasons (ricochet, tripping, etc), the rails systems and soldiers cannot operate in the same space.

An autonomous trackless vehicle target technology will focus on overcoming these shortfalls by focusing on the ability to operate where required (vice where tracks are laid), and in an asymmetric manner. The technology will have to integrate with ballistic proximity and hit detection and other sensors to drive adaptive behavioral reactions. This technology would support training through environment enhancement, engagement feedback, and doctrine execution; and testing through lethality assessment, engagement scoring, and engagement effectiveness.

The objectives of this technology are to:
• Provide a realistic convoy, escalation of force, and close-quarters live-fire training of non-linear movement vehicular targets
• Achieve realistic behavior from units through implementation of Semi-Automated Force (SAF) behavior models and driven by sensor and external data inputs
• Achieve autonomous target control for vehicle target representations
• Achieve maneuverability over a variety of improved and unimproved terrains
• Develop an accurate and reliable acoustic system to score hits and misses
• Integrate safety measures that prohibits autonomous target from leaving the Weapons Surface Danger Zone
• Autonomous target will be able to be controlled in a manner to protect sensitive areas of the target to be protected by natural terrain curves

These concepts and models could then be extended into a dismounted solution in the future.

Autonomous trackless moving targets would provide direct support to training environment realism, and equally provide robust and improved testing targets viable for use in Developmental Test, Operational Test, and Live Fire Test and Evaluation events. The inclusion of autonomous trackless moving targets in testing events would support evasive behaviors and adapter threat profiles.

PHASE I: Study, research, and conduct initial prototype of core technology components for a trackless vehicle target. Synchronization of work being completed by RDECOM, PM ITTS, TACOM, PEO STRI and academia will be required. Determine feasibility of converting current acoustic sensors to fit around a three dimension silhouette, and develop the corresponding timing and modeling algorithms. Study/scope communication networks and protocols to support movement capabilities and mesh communication between targets. Integrate a direct contact hit sensor with engagement location identification. Conduct trade-off study for power systems and power management.

PHASE II: Continue integration of technology into prototype base, and integrate with OneSAF or other emotion engine into the raw prototype for an autonomous trackless vehicle target. Define and integrate reaction behaviors and behavior probabilities, and define skill difficulties and modes of operations (to support styles of learning). Develop intra-target communication to support “group” behaviors, and optimize network performance. Further refine prototype to include ballistic protection and safety features. Integrate sensors for obstacle identification and avoidance. Integrate ability to load terrain maps and synchronize with GPS or other tracking technology.

PHASE III: Transition technology to the Army Program of Record called Future Army System of Integrated Targets.

Develop commercial modes of operations for faux security patrols, or law enforcement training.

REFERENCES:
1) Next Generation Army Targetry System (NGATS) Operational requirements Document (ORD); 11 March 1996

2) TRADOC Pam 525-8-2, “The US Army Learning Concept for 2015”, 20 January 2011.

3) National Training and Simulation Association, “Training 2015: Army”, November 2010.

4) TRADOC "United States Army Training and Leader Development Science and Technology (S&T) Innovations Strategy White Paper", 18 August 2010.

5) Field Manual (FM) 7-1, Battle Focused Training

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KEYWORDS: Autonomous targets, Trackless moving targets, Live Fire Training, Adaptive behavior targets

A12-064 TITLE: Multi-Pulse Single Shot Explosive Power Supplies

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 effort is to methods for generating multiple high power electrical pulses using a single shot explosive driven power supply.

DESCRIPTION: The development of new types of warheads and munitions requires the development of new types of power supplies due to severe volume constraints imposed by currently available platforms and due to the requirement for multiple electrical pulses in order to produce the desired effects on the target. Therefore the objective of this topic is to generate multiple electrical pulses from inherently single shot power supplies that meet the volume constraints of current munitions. The field of Explosive Pulsed Power (EPP) was established in the early 1950s to develop very compact high energy density power supplies. These power supplies either convert the chemical energy stored in explosives into electrical energy or use the shock waves generated by explosives to release the energy stored in materials such as ferroelectrics or ferromagnetic. In general, there are three overall reasons to use explosive power. These are (1) feasibility studies where only a limited number of shots are needed, (2) when large amounts of energy and/or power are needed, and (3) portability for remote testing. Since these generators use explosives, they are inherently single shot devices, which suggests that they typically generate only a single electrical pulse. However, it has recently been demonstrated that explosive driven ferroelectric and flux compression generators are capable of generating multiple electrical pulses. Of particular interest is the Flux Compression Generator (FCG), since it is capable of generating significantly more energy than the other types of EPP generators. Thus, the goal of this topic is to investigate the generation of a train of high power electrical pulses either through the use of special power conditioning circuits or through the use of multi-EPP generators. The specific goal is to generate 8 – 10 electrical pulses with amplitudes of kiloamps and/or tens of kilovolts, while minimizing the mass and size of the overall pulsed power system.

PHASE I: The goals of Phase I are to develop an approach for generating multiple pulses with EPPs and to build and test a brassboard to verify the validity of the proposed approach. This will necessitate the requirement that the proposing firm have access to approved explosive test facilities.

PHASE II: The objective of Phase II is to finalize the design of the multi-pulse FCG based system and to integrate it with various types of loads and perform tests. The proposing Firm must also address any power conditioning and integration issues and assess the impact of various loads on the operation of the multi-pulse EPP system. In addition, the proposing Firm should address manufacturing issues including winding machines that provide the desired winding patterns, mandrel configurations to facilitate winding construction, and so on.

PHASE III: EPPs are applicable to multiple military and commercial applications requiring pulsed power. For example, it has recently been demonstrated that Ferroelectric Generators can be used to initiate multiple blasting caps, which may be of value to the mining industry. Another applications include portable water purification units, portable nondestructive testing systems, portable lightning simulators, expendable X-ray sources, burst communications and telemetry, and oil and mineral exploration. Since several government laboratories and prime contractors are developing advanced munitions, the contractor might want to consider developing a business plan for working with these agencies and companies to facilitate transitioning their technology.

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KEYWORDS: Magnetic flux compression, explosives, pulsed power, ferroelectric generators

A12-065 TITLE: Novel Concept for Mapping Out No Fire Zones for a Scalable Effects High Power Laser System with a Multi-Mission Capability

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: To develop a novel concept for mapping out and maintaining keep out zones (no fire zones) for a scalable effects high power laser system that is capable of conducting a variety of mission. The proposed system should include the capability to accept feeds from the integrated space and air pictures along with the ability to map out terrain and other objects that should not be illuminated with the high power laser beam. The no fire zones must be dynamic and real-time and be able to be injected into the fire control system of the high energy laser weapon system. This topic is important because we need a technique to decrease the amount of time that a high power laser cannot fire due to the possibility of collateral effects on aircraft and satellites.

DESCRIPTION: High power lasers can provide a tremendous benefit to the army for area protection against rockets, artillery, and mortars (RAM) and other potential threats. In addition, high power lasers can also be used to confuse, destroy, or blind surveillance sensors. One of the challenges for a high power laser weapon system is to be able to maintain real-time, dynamic no fire zones. The purpose of this topic is to develop a method, algorithms, and breadboard hardware to demonstrate the ability to dynamically generate and maintain no fire zones for a laser weapon system and provide that information to the high energy laser weapon system fire control. Critical items to be included in developing no fire zones are military and commercial aircraft, military and commercial space assets, ground clutter and terrain including buildings and infrastructure. This topic should include interface descriptions and requirements. It is not the intent of this topic to develop the sensors to the assist in the creation of the no fire zones but to assimilate information received from external sensors, systems, or the high energy laser weapon system itself. High power solid state lasers have the ability to turn on an off very rapidly and there is a desire to keep no fire zones as small as possible so the algorithms, input requirements, and output should be studied and defined in great detail.

PHASE I: Conduct research, analysis, and studies on the selected architecture and develop measures of performance potential and document results in a final report. Provide analysis supporting the error bars associated with the no fire zones. The phase I effort should include modeling and simulation results supporting performance claims. The effort should also produce a preliminary concept and draft testing methodologies that can be used demonstrate the dynamic algorithms and components proposed during the phase II effort.

PHASE II: During Phase II, the concept design and architecture should be completed along with selected components and algorithms to be developed and tested to help verify the design concept should be tested. In addition testing should be conducted to demonstrate the ability to dynamically adjust the no fire zones should be completed.   The data, reports, and tested component hardware and algorithms will be delivered to the government upon the completion of the phase II effort.

PHASE III: There are many applications of a high power laser. Commercial and Military applications include laser remote sensing, laser communication, material processing, and remote target destruction. Industrial high-power applications of high-power solid-state lasers include welding, drilling, cutting, marking, and micro-processing. High energy DoD laser weapons offer benefits of graduated lethality, rapid deployment to counter time-sensitive targets, and the ability to deliver significant force either at great distance or to nearby threats with high accuracy for minimal collateral damage. Laser weapons for combat range from very high power devices for air defense to detect, track, and destroy incoming rockets, artillery, and mortars to modest power devices to reduce the usefulness of enemy electro-optic sensors. The phase III effort would be to design and build a robust device that could be integrated into the Army’s High Energy Laser Technology Demonstrator (HEL TD) to demonstrate the ability integrate multiple inputs into dynamic no fire zone and hand the information over to the HEL TD fire control computer to be able to ensure that the high power laser beam did not cross any no fire zones. Military funding for this phase III effort would be executed by the US Army Space and Missile Defense Technical Center as part of its Directed Energy research.

REFERENCES:

1. W. Koechner, "Solid-State Laser Engineering," Springer-Verlag, 2006

2. Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974

3. Annual Directed Energy Symposium Proceedings available at:
http://www.deps.org/DEPSpages/forms/merchandise.html

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KEYWORDS: High Energy Laser, Scalable Effects, Solid State Laser, Terrain Mapping, Laser No Fire Zones, Air and Space Deconfliction

A12-066		TITLE: Pulse Power and Energy Sources for High Power Microwave and High Power Laser

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 compact pulsed power energy storage devices for use in high power microwave and high power laser systems.

DESCRIPTION: The Army has proposed upgrades for various rocket systems that shows good promise in providing revolutionary warfighting capability. These programs will place extraordinary demands on electrical power and energy storage devices. Innovative research is required to develop high voltage (100-1000 KV) high-energy density storage devices. These energy storage devices must operate at repetition rates of 100 pulses/sec or more. In addition, these devices should be capable of operating at temperatures ranging from -40C to +50C and in high vibration and G load environments. The volume of these devices will be limited to that which can fit into the payload sections ranging from that for the 2.75 inch rocket to that of the MLRS rocket.

PHASE I: Design and build brassboard pulse power energy devices and conduct proof-of-principle experiments.

PHASE II: Design, develop, and demonstrate a pulse power energy storage device that meets the specifications provided in the description. Work with those companies that provide various types of munitions to the Army to address integration and manufacturing issues.

PHASE III: The objective of this effort is to provide to the Armaments and Aviation and Missile Research, Development, and Engineering Centers with power supplies for their various munitions with advanced warheads. Similar power supplies would be of value to the medical industry, manufacturing, and other private sector organizations that rely on pulsed power.

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[1] L.L. Altgilbers, I. Grishnaev, M.D.J. Brown, B.M. Novac, I.R. Smith, Ya. Tkach, and Yu. Tkach, Magnetocumulative Generators, Springer (2000).

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KEYWORDS: Pulsed power, Switch, High Voltage, Electrical Breakdown, High Density Capacitors

A12-067 TITLE: Nanosatellite to Standard Army Handheld Radio Communications System

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

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 communications system (transceiver, antenna, etc) for a nanosatellite that would enable a nanosatellite to transmit/receive with an unmodified, standard Army issue handheld radio, The Army handheld radio is constrained to transmit at a low power level with a standard omnidirectional antenna. The satellite would relay the signal, thereby enabling communication with another Army radio beyond line of sight.

DESCRIPTION: The Space & Missile Defense Command responsive space technology program has been developed to meet the space-related urgent needs of the warfighter in a timely manner. The operational concept calls for responsive space satellites to augment or reconstitute existing “big space” systems. Nanosatellites with masses on the order of 10 kg (22 lbs) or less are receiving an increasing level of attention within the national security community. A large constellation of nanosatellites in multiple Low Earth Orbit (LEO) orbital planes could provide persistent, UAV-like effects for warfighters in one or more theaters. Moreover, dismounted US Army soldiers have a requirement to communicate beyond line of sight on their existing dismounted radios such as the PRC-117 and PRC-152. While man-pack radios with high power batteries and directional antennas can close the link with medium and geosynchronous orbit satellite systems, this man-pack system is frequently not available to dismounted soldiers who are inserted and extracted into remote regions by helicopter. A communications solution is required for the case when a solder has only a low power transmitter with a low gain antenna.

Low Earth Orbit operation greatly reduces the distance between the soldier's radio and the relay satellite, thereby reducing the amount of antenna gain and transmitter power required by the soldier's radio. However, in LEO, a constellation of satellites would be required for persistent communications. The SMDC-ONE is a representative affordable nanosatellite bus suitable for this orbit. A constellation of nanosatellites has the potential to realize significant savings in development, testing, and launch when compared to traditional satellite systems. To realize the potential benefits of the nanosatellites, payload technology must be miniaturized to fit within the size, weight, and power constraints of the nanosatellite. The Block I of the SMDC-ONE design was capable of a maximum of 10,417 bits per second at Ultra High Frequency (UHF) and served well as a technology demonstrator, but is incompatible with existing Army radios.

The Army is looking for innovative solutions that will push the state of the art of the SMDC-ONE's communication capabilities. Contractors are requested to propose changes to the SMDC-ONE transceiver design, while remaining inside the physical size and weight constraints of the current bus. These changes possibly include the un-deployed antenna and radio , as well as other features required to close the communications link. For purposes of the design, contractors should assume relay between two unmodified, standard issue army hand-held radios (AN/PRC117F or AN/PRC152) that are currently deployed in the field. Additionally, the transceiver should have an adjustable data rate mode for command, control and data transfer. Data rates from 1,000 to 56,000 bits per second at UHF frequencies are desired. An S band link in addition to the UHF communications link is desired that would significantly improve the data throughput capabilities over the UHF link is desired. The design may assume that the spacecraft attitude be controlled. The design should also include a calculation of transmitter efficiency and a plan for heat dissipation.

Researchers into nanosatellite to standard army issue handheld radio communications innovations for nanosatellites should take several constraints under consideration, including:

- Bandwidth = 25 KHz (Goal) – 50 KHz(Threshold) including Doppler Shift compensation (+/- 10KHz at UHF)
- Doppler shift compensation should not require the user to have A Priori knowledge of the satellite's position or velocity, i.e., Doppler shift should be compensated automatically
- Maximum data rate = 12 Kbps (Threshold) – 56 Kbps (Goal)
- 25 MHz for S-band channels
- Capability to accommodate multiple users using any multiple access techniques
- Capable of Type 1 encryption (Goal) or AES 256 (Threshold)
- Must include Forward Error Correction (FEC) for the adjustable data rate mode
- Must be able to transmit and receive at both 230-270MHz and 350-380MHz
- Must be tunable in frequency steps of 1KHz
- Must be capable of 2-Frequency Shift Keying (2-FSK) with adjustable frequency deviation from 1KHz-10KHz and Frequency Modulation (FM) (Threshold) and be able to implement other modulations through over the air programming (Goal)
- Minimum Detectable Signal (MDS) = -110dBm (Threshold) or -125dBm (Goal)
- Transmitter radiated power greater than 4Watts (Threshold) or 10 Watts (Goal)
- Size to fit within (10cm x 10cm x 10cm) cube (Threshold) or (10cm x 10cm x 5cm) (Goal)
- Radio must consume less than 14.7 watts
- Effective radiated power should be 8 to 10 watts

PHASE I: Conduct feasibility studies, technical analysis and simulation, and conduct small scale proof of concept demonstrations of a communications subsystem. Develop an initial conceptual approach to incorporate the communications subsystem into an SMDC-ONE class nanosatellite, and include system estimates for mass, volume, power requirements, and duty cycles. Deliverables should include monthly status reports, feasibility demonstration reports and any hardware produced.

PHASE II: Implement technology assessed in Phase I effort. The Phase II effort should include initial communication system designs, mock-ups, and breadboard validation in a laboratory environment. Initial technical feasibility shall be demonstrated, including a demonstration of key subsystem phenomena. Deliverables should include quarterly status reports, design documentation and any hardware produced.

PHASE III: The contractor shall finalize technology development of the proposed nanosatellite communications system and begin commercialization of the product. In addition to military communications, commercial civilian applications for a nanosatellite communications system could include space-based satellite communications. Phase

III should solidly validate the notion of a nanosatellite communications system to enable an SMDC-one nanosatellite to communicate with standard army handheld radios with a low level of technological risk. The goal for full commercialization should ideally be Technology Readiness Level 9, with the actual system proven through successful mission operations. Specifically, Phase III should ultimately produce Nanosatellite communications system to enable an SMDC-one nanosatellite to communicate with standard army handheld radios. The contractor must also consider manufacturing processes in accordance with the president's Executive Order on "Encouraging Innovation in Manufacturing" to insure that the innovations developed under this SBIR can be readily manufactured and packaged for transportation and deployment.

During Phase III, this comms system upgrade could conceivably transition or expand to the appropriate division of the Army Program Executive Office for Missiles and Space (PEO M&S) upon full rate production and deployment. PEO M&S could maintain a stockpile of nanosatellite Communications modules. Simultaneously, commercial versions of the nanosatellite communications innovations could be produced for civilian and scientific applications. Commercial satellite manufacturers could incorporate them into a variety of commercial satellite systems for sale to various interested customers. Commercial companies could also provide competitively priced nanosatellite-based communications services to paying customers, including the national security community.

PRIVATE SECTOR COMMERCIAL POTENTIAL: There is a perceived potential for commercialization of this technology. The primary customer for the proposed technology will initially be the Department of Defense, but there could also be other applications in the areas of commercial satellite communications.

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KEYWORDS: nanosatellite, communications, BLOS, handheld radio, PRC-152, PRC-117

A12-068 TITLE: Sulfur Tolerant Solid Oxide Fuel Cell (SOFC) Stack

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: This project will address the unfulfilled requirement for quiet and efficient generation of electrical power in future military ground vehicles by utilizing solid oxide fuel cell (SOFC) auxiliary power units (APU) that are tolerant to certain levels of sulfur in the fuel. The goals of this effort are to design an SOFC fuel cell stack that: 1) Can generate 10 kW or more of gross electrical power, 2) is tolerant to sulfur content in the incoming fuel reformate stream, and 3) will meet weight and space claim requirements. Promising solutions will be able to operate at sulfur levels of 50 ppm (parts per million) with an objective target of operation at 100 ppm.

DESCRIPTION: Logistic fuels, such as JP-8, currently can contain levels of sulfur up to 3000 ppm (parts per million). This level of sulfur is damaging to the stack in an SOFC system. Thus, sulfur must be removed from the fuel upstream of the stack in order for the system to function properly. Current SOFC technologies can operate at levels of approximately 5 ppm at best, while most require far lower (ppb). The goal of this effort is to design stacks to operate at higher sulfur levels in order to reduce the upstream burden of sulfur removal. Technology, if successful, would be a drop-in solution for the current core-funded fuel cell APU program and would demonstrate increased overall power density and overall system efficiency while reducing overall cost. Project would begin by conducting an analysis of possible configurations for SOFC stack design, resulting in the development of a feasible technical approach to allow SOFC operation at higher levels of sulfur content in fuel reformate. Phase II would execute the technical approach and develop SOFC stacks to demonstrate in a laboratory environment.

PHASE I: Contractor shall identify and design an SOFC solution that will be tolerant to sulfur (50 ppm threshold, 100 ppm objective) in the reformate stream used to fuel the stack. The proposed solution shall have a maximum size of 25 L (including anode and cathode manifolds), a maximum weight of 50 kg, and shall meet a minimum power requirement of 10 kW (gross). Contractor shall submit a plan to fabricate and test SOFC stacks in a laboratory setting. Newly developed/adapted stacks shall ensure compliance to all applicable military standards and specifications, particularly with regard to thermal stress and mechanical vibration. Stack design so identified should include data regarding material availability, ease of producibility, cost projections and statements of current and projected reserves from both domestic and readily available foreign sources. The contractor shall provide the government with a detailed Scientific Report describing the stack design/concept selected and conceptual drawings. During the option period, the contractor shall select and identify materials for stack fabrication and prepare the stack(s) for testing in the Phase II effort.

PHASE II: From the design developed under the Phase I effort, one (1) complete fuel cell stack or bundle of stacks for the specified power output and within the specified size constraints shall be fabricated. Completed stack(s) shall be tested utilizing reformate gas with sulfur levels of a minimum of 50 ppm and a maximum of 100 ppm. Prior to delivery, a complete set of operational tests shall be performed. The contractor shall also provide technical assistance during government evaluation as needed.

PHASE III: Commercial migration of Phase II proof of concept(s) into target markets, military and civilian, either independently or in conjunction with a fuel cell manufacturer. The sulfur tolerance of fuel cell stacks will pay immediate dividends for commercial and tactical environments. In military applications, fuel cells used in APU capacities in tactical vehicles can be replaced by sulfur tolerant stacks which will increase overall power density and improve overall system efficiency.

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1. Fuel Cell Handbook (Seventh Edition), Department of Energy.

2. Sulfur Tolerant Materials for Hydrogen Sulfide Solid Oxide Fuel Cells, Department of Energy.

KEYWORDS: Sulfur Tolerant, Solid Oxide, Fuel Cell, SOFC

A12-069 TITLE: Integration of computational geometry, finite element, and multibody system algorithms for the development of new computational methodology for high-fidelity vehicle systems modeling and simulation

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop the technology and software capability to model and simulate wheeled and tracked vehicles, commercial and military, by integrating computational geometry methods used in CAD systems, nonlinear large displacement finite elements, and flexible multibody systems (MBS) algorithms with the goal of developing MBS vehicle models with significant details. Such models cannot be efficiently or accurately modeled using existing technology. New large displacement finite element meshes consistent with CAD geometry and suited for integration with computational MBS algorithms will be developed in order to build the foundation for a new computational environment that can be used in the analysis of wheeled and tracked vehicles and their interaction with the terrain. The computational frame work will be of general purpose that accommodates modeling and simulation of any MBS system.

DESCRIPTION: General purpose MBS technology currently used by the Army Research Centers for vehicle simulations is only suited for rigid body or small deformation analysis. This twenty-five year old technology cannot capture many details that are important in modern vehicle systems. Such old technology also fails to capture the effect of excessive thermal and impulsive loading conditions that characterize military operations, and therefore, such technology cannot be used effectively in accurate performance evaluation. In order to overcome these serious modeling shortcomings and enhance TARDEC capabilities for vehicle simulation, it is necessary to successfully integrate large deformation finite elements (FE), computational geometry, and MBS algorithms. Such a successful integration will lead to a new generation of computational algorithms that can be effectively and systematically used in developing vehicle models that include significant details that cannot be captured using existing MBS simulation tools.

Despite the large number of FE investigations, the implementation of large deformation FE formulations in MBS algorithms remains one of the main challenges in developing accurate vehicle dynamic models. Existing large deformation vehicle component models range from very simple discrete spring-damper models to detailed inefficient finite element models. The simplified discrete spring-damper models cannot capture significant modes of deformations, effect of distributed inertia, and effect of stress and wear; such models do not also allow for straight forward implementation of general constitutive equations such as the Neo-Hookean or Mooney-Rivlin material models that are necessary to model rubber-like materials. On the other hand, existing finite element beam, plate, and shell formulations that employ simplifying assumptions do not capture deformation modes that can be significant in the case of excessive compressive and/or tensile forces.

Any proposed solution should meet the following minimum requirements in order to be able to advance the state-of-the-art:

(1) The model should result in a minimum set of nonlinear algebraic constraint equations by introducing new geometric concepts and new coordinate sets that allow joint formulations using linear algebraic constraint equations that can be imposed at a pre-processing stage, thereby significantly reducing the computational cost of the simulations.

(2) The model should allow for an accurate deformation description at the joints by capturing significant strain components.

(3) The equations of motion should be systematically formulated resulting in large-displacement deformable bodies with a constant inertia matrix in order to achieve an optimum sparse matrix structure.

(4) The finite elements should allow for a straight forward implementation of general constitutive equations such as the use of different material models for vehicle components such as tires, track links, and soil.

(5) The formulation proposed should allow for introducing thermal loads and ground contact forces that characterize wheeled and tracked vehicle dynamics.

(6) The MBS solution algorithm should ensure that the kinematic constraint equations will be satisfied at the position, velocity, and acceleration levels and there will be no constraint or energy drift.

(7) Numerical implementation should allow for both implicit and explicit solution procedures.

PHASE I: In Phase I, a theoretical and computational study should be conducted to demonstrate the feasibility of the integration of large deformation finite element (FE), computational geometry methods, and multibody system (MBS) algorithms as the basis for the development of new generation of software that are necessary for the simulation and virtual prototyping of military vehicles and equipments. Currently, no MBS algorithms or commercial software that can be used for accurately modeling large deformation or can be integrated with CAD systems are available. The deliverables of Phase I should meet the minimum requirements outlined under the heading "Description" above. The feasibility study should clearly explain how the new computational framework meets the DOD and industry simulation needs.

PHASE II: Research and development results of Phase I should be used as the foundation to start the development and commercialization of a new FE/MBS computer code that allows for the integration of computational geometry methods. This code should be designed to meet DOD needs for the simulation of vehicle system models with significant details and their interaction with the terrain. The code should allow for efficient modeling of rigid and flexible components; and should also allow for the development of new nonlinear finite element meshes with accurate geometry. This new technology and the software should meet the needs of DOD as well as automotive and aerospace industries.

PHASE III: In Phase III, the technology developed and software prototyped in Phase II should be transitioned into a new commercial modeling and simulation (M&S) tool for use in commercial and military applications. The technology can also be inserted into existing commercial M&S tools that are already in use by industry and government. Commercial customers are multitude, such as automotive, aerospace, robotics, and heavy machinery. Military applications involve ground vehicles, both wheeled and tracked. Funds from industry and other government agencies should be sought for further developing the technology. A closer relationship with industry customers and federal laboratories should be established in order to enhance the new software capabilities and demonstrate its use in multi-physics problems.

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KEYWORDS: flexible body dynamics, vehicle system, vehicle-terrain interaction, nonlinear finite-elements, multi-body systems, computational geometry, modeling and simulation

A12-070 TITLE: Efficiency enhancement in a unmanned/robotic vehicular system based on drive cycle and driving pattern prediction

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Intent of this work is to use artificial intelligence technology to predict the drive cycle and driving pattern and develop strategy to maximize fuel economy in an unmanned/robotic vehicular system, which can also be applicable to legacy vehicles, and also future propulsion systems (e.g. electric/hyrbid).

DESCRIPTION: It is well recognized that fuel economy in a vehicle depends to a substantial extent on the drive cycle and driving pattern. Even when traversing an identical path, the fuel economy of the vehicle can be different, based on the driver/operator. The intent of the proposed work is as follows. An intelligent controller will be developed, whose job will be to monitor different physical variables based on various sensors within the vehicle (with particular focus on unmanned/robotic vehicles) e.g. speed, acceleration, fuel flow, battery current and voltage, and information based on human operator's visual perception or camera, and other sensors monitoring outside situation, and then, based on that information, the intelligent controller will figure out or predict the pattern of the driving cycle and style of the operator (which, in the case of a unmanned/robotic system will be a remote operator or it could be fully autonomous) at the present time and also in the future. These could possibly be classified under different categories of drive cycles and operator pattern. In case of an unmanned vehicle, the driving pattern might imply the pattern of remote operator in place of the driver who may be controlling the vehicle based on remote sensing. This study involves learning of the drive cycle and driver (which can be remote) category from actual running of a vehicle. It is also possible to develop such knowledge through driving simulators. Once this stage has been crossed, the next step will be to use the information fruitfully to control the fuel controller and/or power management controller within the vehicle. In the case of a non-electric vehicle this will generally imply controlling the IC engine fuel controller. In case of an electric/hybrid propulsion of an unmanned or robotic vehicle this will also include control of the electric propulsion system, along with the IC engine controller. The control methodology has to be adaptive as well. This means that as the vehicle ages, and its parameters change, the controller has to learn adaptively in order to achieve maximum fuel economy. The challenge lies in the fact that sometime optimizing fuel economy while maintaining a particular performance requirement might call for compromise. This might, from time to time, imply some amount of performance reduction, while improving fuel economy. In many instances it may be the case that the undue over performance is really not needed. It may be that this over performance demand is merely due to a particular operator of the vehicle (which can be remote operator for an unmanned/robotic system) whose style is more aggressive etc. These conflicting requirements have to be understood clearly and incorporated within the controller. The end result of the work will be an embedded controller (with the algorithm) which should be integrated within the vehicular system. The benefit of the work will be in terms of better fuel economy and hence enhanced survivability. It should be noted that the work is beneficial not only to the various DoD entities, but also to commercial automotive sectors, including manned and unmanned vehicle (robotic system) entities.

PHASE I: Analyze the overall problem. Discuss feasibility of using the technology for enhancing fuel economy by predicting drive cycle and driver/operator (which, for an unmanned/robotic vehicle will be remote) behavior. Develop the outline of methodology including analytical details as needed. Modeling and simulation can be undertaken initially to illustrate the principles. Findings are to be submitted in the form of technical reports along with any modeling and simulation as applicable.

PHASE II: Implement detailed modeling and simulation based on Phase I work. Demonstrate the benefit through modeling and simulation. Implement it in the form of a fuel control and/or part of a power management module of in a vehicle, which should be initially an unmanned/robotic system with either a propulsion system which can be IC engine based or pure electric or hybrid, and demonstrate the effect of the technology on fuel economy.

PHASE III: Utilize the Phase II technology in a prototype vehicle. Commercialize the technology.

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2. Y. Murphey, Z. Chen, L. Kiliaris, J. Park, M. Kuang, A. Masrur, and A. Phillips, "Neural Learning of Driving Environment Prediction for Vehicle Power Management", IEEE World Congress on Computational Intelligence (WCCI), IEEE International Joint Conference on Neural Networks (IJCNN), 2008

KEYWORDS: Intelligent control, neural network, fuzzy algorithm, driver pattern, unmanned vehicle, UGV, robotic vehicle, electric/hybrid vehicle, power management.

A12-071 TITLE: <u>Force and Moment Tire Characterization</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop a method for accurately measuring force and moment data for heavy-duty, military grade tires under the extreme range of operating loads seen by military vehicles.

DESCRIPTION: Over the past two decades, the Army has introduced a growing number of wheeled combat vehicles such as the MRAP (Mine-Resistant, Ambush-Protected Vehicle) and the M1114 Humvee in an attempt to build a lighter, more nimble fighting force. These wheeled vehicles are faster and more agile than tracked vehicles, but they also provide new challenges. While the operating characteristics of tracks are somewhat predictable and consistent, those of tires vary greatly depending on tire construction, tread pattern, deflection under load, dynamic performance, and air pressure (or loss thereof). These measures have a significant affect on the performance of the vehicle, including its ability to perform emergency maneuvers and traverse various terrains while avoiding dangerous situations such as rollover [1,2].

Unfortunately, tire testing capabilities for heavy duty tires are currently very limited in scope due to the large forces required. The large normal and lateral loads prevent testing on trailer systems due to undesirable trailer motion. The forces are much too large for testing on most belt machines, which are the only current option to trailers for testing on a flat surface, because they destroy the water or air bearing systems below the belt. In the few conditions under which heavy duty tires have been tested on belt machines, the results have proven to be highly nonlinear compared to expected results on asphalt, due mainly to the different grip characteristics between asphalt and the steel belt or sandpaper interface used to emulate asphalt [3]. For these reasons, drum machines are used to collect data for heavy duty tires; unfortunately, these machines result in a concave contact patch and, like belt systems, fail to produce accurate grip data on the steel or sandpaper surfaces used.

The Army is seeking a unique, new methodology that will overcome these shortcomings in existing tire testing capabilities for heavy duty tires. The new technology should provide an innovative solution that will allow testing of heavy duty tires under operating conditions indicative of those seen by military vehicles in the theater (normal loads of up to 25,000 lbs, lateral loads of 10,000 lbs, and speeds of 50 mph). The successful project will result in data that closely emulate the forces and moments actually generated by a tire on a flat, paved surface. The results obtained from the new approach should correlate closely with on-road data, overcoming the nonlinearities obtained from drums and belts with sandpaper or metal interfaces.

Military vehicle manufacturers will be able to use these data to more accurately compare tires from multiple tire manufacturers for performance. In addition, vehicle manufacturers will be able to simulate vehicle performance in the theater during the vehicle design stage using data from different tires, thereby providing the ability to optimize the combined system by matching tire characteristics to each vehicle. By acquiring these data, military vehicles can be optimized in a simulation environment prior to building prototypes, resulting in significant cost savings and shorter turnaround times to the manufacturer and the Army. Also, these data can be used to better predict and prevent rollover, to optimize stopping distance and traction, and to monitor performance consistency.

The innovation exists in that no tire testing capability has ever been realized that allows the controlled motion and instrumentation required to accurately emulate a real vehicle in a realistic operating environment. Almost all testing equipment used today tests at quasi-steady state conditions, at fixed temperatures, at speeds that are unrealistically slow, and on artificial surfaces such as sand paper or steel drums. This project will greatly expand both capabilities and accuracy of tire testing. For example, Table 1 compares the capabilities of typical lab-based systems (the most common tire testing systems) and the proposed design.

Potential research that will result from this project includes:
• Determination of influence of varying tire stiffness under camber / roll on rollover
• Traction characteristics of tires in various terrains, quantification of significant soil parameters
• Wet traction characteristics (longitudinal and lateral)
• Studies of interference of run-flat rings with tires and resulting tire characteristics
• How changes in environmental conditions (temperature, humidity, etc.) affect vehicle performance in the theater.

Table 1: Comparison of Lab-based, Trailer-based, and Proposed Systems
* Real Road Surface
- Lab Systems (Belt, Drum) = Poor or No Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Belt results can be highly nonlinear when compared with on-road data

* Dynamic Event Simulation
- Lab Systems (Belt, Drum) = Fair or Likely Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Belt systems are extremely limited in load capacity as are trailer systems; drum systems cause unrealistic contact patch distortion.

* Heavy Duty Load Capacities
- Lab Systems (Belt, Drum) = Fair or Likely Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Bearings restrict vertical load on belt systems. Drums introduce concave contact patch. Proposed system only one suited for heavy loads on flat surface.

* Wet Traction, Ice, Snow
- Lab Systems (Belt, Drum) = Poor or No Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Belt systems struggle to emulate real wet roads. Proposed system can utilize proving ground knowledge to test wet traction accurately.

* Road Features (cleats, rumble strips)
- Lab Systems (Belt, Drum) = Fair or Likely Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Drum is only lab system for cleat testing, and is greatly restricted to low speed. Proposed system ideal for this testing.

* Dynamic Vertical Stiffness and Impingement during Camber and Roll.
- Lab Systems (Belt, Drum) = Fair or Likely Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Belts cannot withstand high loads. Proposed system can address loads and required articulation for dynamic testing.

* Variations in Terrain (sand, mud, dirt, gravel, etc.)
- Lab Systems (Belt, Drum) = Poor or No Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Belt, drum systems only emulate asphalt, and do that with sandpaper. Proposed system could measure any terrain prepared by the ARMY in rail configuration.

* Quantifying tire performance under varying environmental conditions
- Lab Systems (Belt, Drum) = Poor or No Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Lab systems typically held at constant temperature. Cannot model effect of oils coming out of pavement under heat. Proposed system on real pavement is ideal.

* Normal Testing of Run-Flats
- Lab Systems (Belt, Drum) = Fair or Likely Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Belt system damage likely, particularly when tires fail. Drum systems produce artificially high contact stresses due to concave contact patch.

* High Cornering Loading of Run-Flats
- Lab Systems (Belt, Drum) = Poor or No Capability
- Proposed SBIR Solution = Good or Excellent Capability
Comments: Used to measure the changing characteristics of the tire (stiffness, etc.) when impingement occurs. Requires high load and articulation capacities

PHASE I: Develop several concepts that advance heavy duty tire testing capabilities in the following areas: a) provide force and moment testing of heavy duty tires under free spinning (i.e., not driven or braked) operating conditions indicative of those seen by military vehicles in the theater (normal loads of up to 20,000 lbs, lateral loads of 10,000 lbs, and speeds of 50 mph); b) provide a solution that will overcome the inaccuracies generated by sandpaper or metallic surfaces by generating data that closely correlate to on-road data; and c) provide a solution that can assess a tire’s contribution to rollover by measuring susceptibility to tripping hazards, variations in stiffness due to tire orientation, and other contributors to rollover. Identify the associated advantages and disadvantages of each system, and propose a solution based on a decision process. Explain the innovation in each concept and how each overcomes the shortcomings of existing tire testing facilities. Provide a proof of concept (via simulation models) of the tire articulation, camber control and drive system and how the overall system is able to improve the emulation as well as repeatability of real conditions as compared to existing testing methodologies and technologies.

PHASE II: Based on the findings in Phase I, the objectives in Phase II would be to develop a detailed design and fabricate a prototype for testing and proof-of-concept. The detailed design should encompass aspects of carriage design, tire articulation, camber control, tire actuation, system drive and the incorporation of metrology instrumentation. The contractor shall produce a validated design and fabricate a prototype to verify the system's performance and abilities. The prototype system will be tested for verification of dynamic event simulation, durability and automated tests, and baselining with traceability to current standards which lead to better understanding of tire interaction with road surfaces with quantifiable data.

PHASE III: Potential military applications include, but are not limited to:
• Acquiring force and moment data from a heavy duty tire under normal operating conditions for improved tire characterization. These data will aid in the tire selection process and tire performance validation activities.
• Streamlining the development stage of a military vehicle through improved simulations made possible by accurate tire data under realistic conditions.
• Assessing a tire's contribution to rollover.
• Acquiring data for durability studies using road features such as cleats to acquire force data to be input into software models such as F-Tire and others, with the intention being to reduce vehicle failures due to input forces from the tire/wheel.
• Conducting testing of run-flat tires to assess performance, durability, and failure modes.

Commercial applications are similar and apply principally to over-the-road tractor trailers. In particular,

• Acquiring force and moment data that closely correlate to tire performance on a paved surface in order to raise the accuracy of vehicle simulations during the development stages. This is particularly important, as the heavy trucking industry is largely custom built to customer specifications, and each truck produced has different weight distributions, tires, etc. The ability to virtually model performance is critical to meeting federally mandated standards such as braking distance (FMVSS-121) and the proposed electronic stability control (FMVSS-126) protocols for trucks.
• Conducting durability testing (for example, cleat testing) to acquire force data to be input into software models such as F-Tire and others. Failures of chassis components pose a significant problem to the trucking industry, as well as a safety concern to those in the vehicle and surrounding vehicles.
• Conducting rolling resistance studies for improved fuel economy.

Effort to produce these to benefit the private sector

** Given the financial commitment for this type of project, it is anticipated that only one will be built initially. However, we anticipate that this type of device may become an industry standard upon which all existing tire testing machines will be benchmarked (to compare, for example, flat belt machines with real road surfaces, etc.) Though the volume will be small due to the costs involved, industry must comply with federal mandates for safety dictated by National Highway Traffic Safety Administration (NHTSA)

** A secondary consideration is that, while this one device will service heavy-duty military concerns, many perturbations of the concept will likely emerge from this first design. For example, smaller scale automotive and light truck carriages will be different from the heavy duty case although similar in concept. Various other specialized carriages, such as those designed to measure high resolution data such as rolling resistance and drift and pull, or high speed data for the racing or high end sports car industries, will result in significant opportunity to either a) produce these carriages for sale, or b) to produce the required capabilities for a single company that provides testing services rather than producing and selling the machinery.

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KEYWORDS: durability, dynamics, rollover, run-flat, safety, simulation, tire, testing, vehicle

A12-072 TITLE: Development of affordable high-performing passive exhaust systems and manufacturing technology

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Enable the Army's ability to provide the war fighter affordable, very quiet, exhaust systems that remain within typical Army constraints such as backpressure, weight, size, etc.

DESCRIPTION: Commercial market engine exhaust applications are distinctly different from Army applications. Commercial truck mufflers are tailored to allow large trucks to pass federal noise requirements, which are more lax than military vehicle non-detectability requirements. The impact on the Army is that the low-cost, commercially available mufflers are inadequate for Army use. Commercial mufflers are made affordable through high volume manufacturing methods. Army mufflers, on the other hand, are produced in low volume. To remain within cost, weight, and other constraints, trade-offs are made that affect the acoustic and flow performance. There is a technology gap that results in the fact that the cost, size, and/or weight of a truly quiet custom exhaust system for an Army application becomes impractical.

The state of the art for passive mufflers can be seen by looking at the large quantity of proprietary innovative designs in the performance exhaust market which could possibly be used to make quiet exhausts rather than the current focus of tuning exhausts to sound "powerful". Additionally the commercial heavy diesel market has a lot of proprietary innovative designs that address federal highway noise requirements and compression braking. Again, the application of these proprietary technologies was not geared towards making very quiet exhausts. On the manufacturing side, there are some companies making polymer exhausts which could allow great flexibility in design and lower manufacturing costs.

Ultimately, this effort would culminate in a demonstration of quiet muffler designs on three Army vehicles (one each for a light, medium, and heavy platform) showing the quietest possible performance attainable within space, weight, cost, and back pressure constraints. The specific focus for research is the trade-off between life cycle cost and performance. Offerers are to be aware that a wide range of vehicle operating scenarios should be considered such as long periods of idling, rough off road driving, convoys, driving through towns/villages, driving through large open spaces (i.e. plains, deserts, fields, etc), silent watch, etc.

The research performed should show clearly the trade-offs encountered and burdens associated with different elements of the exhaust including combinations (expansion chambers, resonators, baffles, etc). These performance parameters should be proven using modeling, simulation, and testing.

PHASE I: The offerer shall demonstrate knowledge in the subject area and how their knowledge / expertise will be used to address the problem (for example, through a report which details the nature of the sound emitted by exhausts, the effect(s) on backpressure, lists currently available exhaust technologies, details their claimed performances / burdens, assesses how the technologies function, and finally evaluates affordable low-volume manufacturing methods). Novel design concepts are encouraged and may be included if desired. The offerer shall submit a detailed engineering plan for the Phase II effort.

PHASE II: The main deliverable shall be “Very Quiet” PASSIVE exhaust systems for three demonstrator vehicles along with the each design's technical data packages. The secondary deliverable is a detailed description of the manufacturing capability to produce the systems in low volume and low cost.

Three demonstrator exhaust designs will be developed for the following vehicles: 1) LTATV(Kawasaki Teryx), 2) MRAP All-Terrain Vehicle (MATV), and 3) Bradley Fighting Vehicle. A quantity of three (3) each shall be manufactured using the developed manufacturing system. The manufacturing system shall be stable enough that reasonable tolerances are achieved.

Each vehicle will be outfitted with its demonstrator muffler and ran through a series of tests such as idle, tactical idle, constant speed drive by at various speeds, wide-open-throttle accelerations, and "rock hops". Additional testing will be performed to determine the insertion loss and backpressure of each design.

Each design will strive to achieve maximum noise reduction and minimum cost while meeting engine specific backpressure requirements. To a lesser extent, each design / proposal will be evaluated based on minimizing size and weight and maximizing durability and ease of installation. Each demonstrator design shall be cognizant of the vehicle it is being applied. That is, each design shall make reasonable attempts to remain within relevant vehicle specific constraints such as those above. The designs shall not have an adverse effect on vehicle performance, ground clearance, safety, crew compartment temperature, etc. Demonstrator designs must be readily adapted to the vehicles and safely tested without causing damage to the vehicle and/or exhaust system.

Target performance figures are at least 35 dB (linear and A-weighted) noise reduction at a cost of less than $500 per vehicle (at a target manufacturing volume of 100 units).

A final report shall be written that details the manufacturing concept that allows for low-cost, low-volume production of customizable very quiet passive mufflers. The report shall also include an in-depth engineering investigation of all design concepts and a characterization of their effects on acoustic and backpressure performance along with the muffler design methodology (to include recommended modeling / simulation / testing methods).

PHASE III: Potential Army applications include most existing and future ground vehicles. The commercial uses include off-highway, construction, law enforcement, etc. Additionally, a low cost custom exhaust system manufacturing process will allow automotive aftermarket custom exhausts to be produced at a lower cost opening a new market segment.

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KEYWORDS: low cost, low volume, manufacturing, quiet, passive, exhaust, muffler, stealth, silencer, signature

A12-073 TITLE: Stability Control Improvement and State Detection for Autonomous Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

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

OBJECTIVE: Develop a driver alert and vehicle control system for rollover avoidance in off-road conditions, using low cost look-ahead terrain characterization.

DESCRIPTION: Only for the Mine Resistant Ambush Protected (MRAP), a DoD study shows that the rollovers are about 42 percent of recorded mishaps, and represents the category resulting in the greatest loss in vehicle damage and casualties. The main cause for such rollovers is terrain and currently cannot be addressed by existing vehicle stabilization systems.

The automotive industry presently seeks enhanced vehicle control through commercial integration of Electronic stability control (ESC) and Roll stability control (RSC) with other driver assist systems, i.e. active steering, adaptive cruise control (ACC), lane departure warning, traffic sign recognition, path prediction, safety digital map, driver alertness, data fusion, obstacle detection and classification. Such state-of-the-art vehicle control and stabilization can be achieved in passenger vehicles, but terrain, load and weight conditions for military vehicles are currently much more challenging for these systems. On the other hand, experience accumulated in the robotic community may be used to bridge the gap between military and passenger vehicle control. The key ingredient for a predictive state estimation and vehicle control in off-road conditions is look-ahead terrain characterization. Various robotic systems use enhanced perception from LIDAR, video and infrared cameras, radars, and ultrasound devices, for terrain and obstacle detection and classification. The state of the art in terrain characterization could be referenced to experience accumulated in the DARPA Challenge, however, the sensors and systems that provided the needed capabilities are quite expensive.

In response to these challenges, proposals are sought which offer an affordable driver alert and vehicle control system that could be integrated into medium and light tactical vehicles, with variable load, operating in day and night, off-road conditions, rolling at a maximum speed of 40 km/h. The driver alert and vehicle control system should be able to predict a rollover or yaw stability event due to: driver not being able to estimate the edge and driving to close to it; soft shoulder or ground surface gives way; uneven terrain when the vehicle falls from higher elevation to a lower elevation; driver swerving to avoid pothole or hitting a curb, median, or pothole. Additionally, it should provide commands for throttle, steering and brake control and be able to be integrated into an optionally unmanned platform for rollover avoidance.

To achieve this, at a minimum the following technology needs should be addressed:
- minimum 2 s look-ahead sensing time to detect edge, curb, terrain inclination, terrain roughness, potholes, and ditches, and provide warning and/or control
- use of low cost automotive sensors for off-road terrain characterization, such as visible light and infrared stereo camera, and radar
- vehicle state estimation compatible with typical sensors used in RSC, such as for: wheel speed, brake pressure, steering-wheel angle, yaw rate, roll rate, lateral acceleration, and load at the axles
- estimation of vehicle’s center of gravity for variable loads
- sensor fusion
- estimation of terrain friction at the wheels
- algorithms for vehicle control, based on terrain characterization and vehicle state estimation
- real-time throttle, steering and brake closed-loop control using CAN bus commands
- simple user interface for driver alert

PHASE I: Develop a proof-of-concept of a driver alert and vehicle control system for rollover avoidance, in a modeling environment, generic enough that it can be applied to various military vehicle types through modeling and simulation with only minor changes. The modeling environment should consider vehicle state estimation, off-road conditions at speeds up to 40 km/h, and look-ahead sensing able to provide a minimum 2 s warning time. The deliverable for this Phase is a Technical Report showing the feasibility through algorithm development, estimated latencies, different look-ahead sensor evaluation, and preventive control efficiency.

PHASE II: Using the Phase I design requirements and technical documentation, the contractor should fully develop, fabricate and deliver a prototype of the driver alert and vehicle control system for rollover avoidance. The delivered system should include automotive low-cost sensors, such as camera and radar, to detect road edges, curbs, terrain inclination and roughness, potholes, dips and ditches. The capabilities of the system should be demonstrated through prototype integration onto a physical vehicle chosen by the contractor and approved by the government. The environment and operating conditions for the final demonstration should be off-road, day and night, at speeds ranging from 20 km/h to 40 km/h.

PHASE III: Closer to commercial Phase III should involve integrating the driver alert and vehicle control system onto multiple military vehicles that will be used for the Autonomous Mobility Appliqué System (AMAS) program. The driver alert and vehicle control system could be integrated into commercial vehicles that are currently developed to be optionally manned-unmanned, and it should be capable of being applied to various military vehicle types with only minor changes. This phase should also leverage the AMAS Joint Capability Technology Demonstration (JCTD) by building on its stability control baseline capabilities.

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KEYWORDS: Unmanned Ground Vehicle, Terrain Characterization, Vehicle Control, Autonomous, State Detection

A12-074 TITLE: Haptic Feedback for a Virtual Explosion

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop approaches to create an impulse force that simulates the feel of debris strikes from a virtual explosion (i.e. IED) or bullet strikes to enhance indoor immersive training systems' realism.

DESCRIPTION: Virtual Training Systems have successfully trained the Warfighter for several years. As successful as the systems have been, there has been a technology gap – tactile feedback from the simulated training environment. For Soldiers training for reconnaissance missions or convoys, they will see and hear flashes representing bullets and explosions, their simulated vehicle will "react" to bullet or explosion damage, but the Soldiers themselves do not receive any tactile feedback. A method to generate an impulse force to provide tactile feedback for the trainees for indoor virtual training is needed that provides both a sense of the force and the sound. It must be safe for indoor use, must not injure the trainees nor adversely affect the performance of the simulator equipment. The impulse force should not require the trainees to wear any special equipment. With these factors in mind, an innovative solution is needed to simulate for the human training environment the force felt from debris of an IED explosion, and the force felt by a bullet strike.

Current methods of providing tactile feedback are tactile devices, air jets, fans, and air cannons. Tactile devices are attached to the user. The problem with these devices is that they are always in contact with the user thus leading to unwanted extraneous touch sensation. For air jets, the reachable distance of an air jet is determined by the diameter of the nozzle and the velocity of the air flow, which results in the trade-off between the spatial resolution of the pressure on the skin and the distance from the device to the skin. Fans and air cannons only provide a rough force feedback with limited temporal and spatial properties.

The fields of telerobotics and telemedicine were also investigated. Telerobotics focuses on controlling robots from a distance using teleoperation. A telemanipulator is used to control the robot either from a close distance or a very remote distance. Telemedicine is the use of telecommunications and information technologies to provide health care at a distance. It can be as simple as a live video and audio connection to speak with a healthcare professional, or as complex as a physician performing surgery using telerobotics. In the latter case, the robotics utilized by the surgeon may use haptics to give the surgeon a sense of touch. Telerobotics and telemedicine did not yield any usable technologies as they are not interested in precisely generating and precisely delivering an impulse force several feet away in three dimensional space.

PHASE I: Design a concept for tactile feedback to add a more real feeling for indoor virtual training systems. Specifically, simulate the force felt from the debris strikes from an IED explosion and/or the force felt by a bullet strike. The effort should clearly address the strength, the range, and the accuracy of directing the generated impulse force field. Recent advances in directed ultrasound and focused microwaves represent two, of many, possible mechanizations. The proposed design concept must address the safety of the trainees, as well as any impact on the equipment (i.e. RF, EMI, etc.).

PHASE II: Construct and demonstrate the operation of a prototype. Included in this effort shall be two safety test plans for determining the safety of the system. The first safety test plan shall demonstrate the safety of the system without using human test subjects. The second safety test plan shall demonstrate the safety of the system with human test subjects. After successfully proving the safety of the system without human test subjects, demonstrate the prototype in accordance with the design success criteria as outlined in Phase I. If the prototype demonstration is successful, testing the safety of the system using human test subjects shall be done. Upon successful completion of the second safety test, the prototype may be integrated into one of PEO STRI's virtual training systems/sites to enhance the immersive training experience.

PHASE III: There are two benefits to developing impulse force interactions for Army Training Systems. The first is that it will significantly enhance the training experience by starting to provide tactile feedback to the trainees. The second is the potential to provide tactile interaction with holograms. This aligns with the ultimate goal for simulation and training, to provide a total immersive experience with three dimensional interactive holograms that provide tactile feedback.

The value of impulse force interactions is not just limited to the Army; it can also be used for commercial systems. The ability to provide tactile feedback is the next logical step which will provide advancements in gaming, movies, manufacturing, and medicine. Currently, tactile feedback is being used in theme parks on rides and in theater presentations. It is considered a 4-D effect, describing a special effect which usually involves lasers, vapor, or tactile feedback synchronized to a 3-D film narrative or to the vehicles in a 3-D theme park ride. In a highly competitive market, the theme parks are always looking for an enhanced experience to deliver to their customer. To date, 4-D rides and films have proven to be very popular attractions at the theme parks. A more precise method of delivering tactile feedback would widen the range of special effects used for the rides and the theaters, enhancing the guest's experience and the owner's revenues.

A second commercial application would be for games, a substantial market that is highly competitive. To retain market share, new and higher fidelity gaming experiences such as tactile feedback are always sought.

METRICS

• System shall be safe to use. It must not cause any adverse medical effects to the trainees and must not damage training equipment.
• The impulse force should have the ability to be accurately delivered to a specific point.
• System must accurately simulate the trajectory of flying debris from an explosion or the trajectory of a bullet.
• Synchronization of the sound from an explosion or bullet along with the tactile reaction from the impulse haptic.

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