U.S. ARMY
SUBMISSION OF PROPOSALS

Topics

The Army strives to maintain its technological edge by partnering with industry and academia. Agile, free thinking, small, high tech companies often generate the most innovative and significant solutions to meet our soldiers’ needs. The Army seeks to harness these talents for the benefit of our soldiers through the SBIR Program.

The Army participates in one DoD solicitation each year with a two-tiered Phase I and Phase II proposal evaluation and selection process using the criteria described in section 4.2 and 4.3. Army scientists and technologists have developed 258 technical topics with the Phase III dual-use applications for each that address Army mission requirements. Only proposals submitted against the specific topics following this introduction will be accepted.

The Army is transforming to better meet small-scale contingencies without compromising major theater war capability. This transformation has had a major impact on the entire Army Science and Technology (S&T) enterprise -- to include the SBIR program. To supply the new weapon systems and supporting technologies needed by the transformed Future Force (FF), the Army initiated the Future Combat Systems (FCS) program. The SBIR program is aligned with current FCS and FF technology categories -- this will be an ongoing process as FF/FCS needs change and evolve. All of the following Army topics reflect FF and FCS technology needs. Over 75% of the topics also reflect the interests of the Army acquisition (Program Manager/Program Executive Officer) community.

Recommendations for Future Topics

Small Businesses are encouraged to suggest ideas that may be included in future Army SBIR solicitations. These suggestions should be directed to the SBIR points-of-contact at the respective Army research and development organizations listed in these instructions.

Submission of Army SBIR Proposals

All proposals written in response to topics in this solicitation must be received by the date and time indicated in Section 6.2 of the introduction to this solicitation. Submit the proposal(s) well before the deadline. Late proposals will not be accepted.

All Phase I proposals must be submitted electronically via the DoD SBIR/STTR Proposal Submission Site. Each proposal must include the Proposal Cover Sheets along with the full Technical Proposal, Cost Proposal and Company Commercialization Report. A confirmation of receipt will be sent via e-mail shortly after the closing of the solicitation. Selection and non-selection letters will also be sent electronically via e-mail.

The entire proposal must be submitted using the online submission system. Do not send a hardcopy of the proposal. Hand or electronic signature on the proposal is also NOT required. Small businesses may access the website any time (prior to 12 August 2004) to upload or update a Technical Proposal and create or edit the Cover Sheets, Cost Proposal and Company Commercialization Report. The small business is responsible for performing a virus check on each proposal before it is uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. The submission site does not limit the overall file size for each electronic proposal submission. However, file uploads may take a great deal of time depending on the internet provider’s connection speed and the size of the file. If you experience problems uploading a proposal, call the Help Desk (toll free) at 866-724-7457. The Army WILL NOT accept any proposals which are not submitted through the on-line submission site (http://www.dodsbir.net/submission).

Reminder! Please submit proposals early to avoid delays due to high user volume.
Phase I Proposal Guidelines

Visit the Army SBIR Website to get started (http://www.aro.army.mil/arowash/rt/). This page provides information about our mission and organization and a link to the DoD-wide SBIR proposal submission system (http://www.dodsbir.net/submission) that leads you through the preparation and submission of your proposal.

Small businesses that participate in this Solicitation must complete the Phase I Cost Proposal not to exceed the maximum dollar amount of $70,000 and a Phase I Option Cost Proposal not to exceed the maximum dollar amount of $50,000. Phase I and Phase I Option costs must be shown separately but may be presented side-by-side on a single Cost Proposal. The Phase I Option proposal must be included within the 25-page limit for the Phase I proposal.

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

The Army will not accept Phase I proposals which exceed $70,000 for the Phase I effort and $50,000 for the Phase I Option effort.

A Company Commercialization Report must be included with each proposal submitted to the Army. Refer to section 3.5d at the front of this solicitation for detailed instructions on the Company Commercialization Report. If commercialization information has not been updated in the past year, or you need to review a copy of the report, visit the DoD SBIR Proposal Submission site. Please note that improper handling of the Commercialization Report may result in the proposal being substantially delayed and that information provided may have a direct impact on the evaluation of the proposal. The Company Commercialization Report does not count toward the 25-page Phase I proposal limitation.

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

Selection of Phase I proposals will be based upon scientific and technical merit, will be according to the evaluation procedures and criteria discussed in this solicitation, and will be based on priorities established to meet the Army’s mission requirements. The first Criterion on soundness, technical merit, and incremental progress toward topic or subtopic solution (refer to section 4.2 at the front of this solicitation), is given slightly more weight than the second Criterion, which is given slightly more weight than the third Criterion. When technical evaluations are essentially equal in merit between two proposals, cost to the government may be considered in determining the successful offeror. Due to limited funding, the Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded.

Be reminded that section 3.5.a of this solicitation states: “If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet on the DoD SBIR/STTR website (www.acq.osd.mil/sadbu/sbir/); therefore, do not include proprietary or classified information in these documents. DoD will not accept classified proposals for the SBIR Program.” Note also that the DoD web site contains timely information on firm, award, and abstract data for all DoD SBIR Phase I and II awards going back several years.

Proposals not conforming to the terms of this solicitation and unsolicited proposals will not be considered. Awards will be subject to the availability of funding and successful completion of contract negotiations. The Army typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award, at the discretion of the Contracting Officer.

Small businesses that received a non-selection letter may request a debriefing. The debriefing request must be made electronically within 30 days of notification of non-selection via the website provided in the non-select letter.
**Phase II Proposal Guidelines**

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

Small businesses are required to submit a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of $730,000. During contract negotiation, the contracting officer may require a cost proposal for a base year and an option year. These costs must be submitted using the Cost Proposal format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. At the Contracting Officer’s discretion, Phase II projects may be evaluated after the base year prior to extending funding for the option year.

Small businesses that participate in the Fast Track program do not require an invitation, but must submit an application and Phase II proposal by the Phase II submission date.

Cost-sharing arrangements in support of Phase II projects and any future commercialization efforts are strongly encouraged, as are matching funds from independent third-party investors, per the Fast Track program (see section 4.5 at the front of this solicitation) or the Phase II Plus program. Commercialization plans, cost-sharing provisions, and matching funds from investors will be considered in the evaluation and selection process. Fast Track proposals will be evaluated under the Fast Track standard discussed in section 4.3 at the front of this solicitation.

The general concept of the Phase II Plus program is to provide additional Phase II SBIR funding to small businesses that qualify by obtaining non-SBIR funds from the government, private sector, or both for the purpose of extending Phase II R&D efforts beyond the current Phase II contract to meet the product, process, or service requirements of a third party investor, and to accelerate the Phase II project into the Phase III commercialization stage. Phase II Plus funds must be used for advancing the R&D-related elements of the project however third-party investor funds can be used for R&D or other business-related efforts to accelerate the innovation to commercialization. Under Phase II Plus, additional funds may be provided by modifying the Phase II contract. When appropriate, use will be made of the flexibility afforded by the SBA 1993 Policy that allows Phase I + Phase II SBIR funding to exceed $850,000. Phase II Plus funds, subject to availability, will be matched dollar-for-dollar with third-party funds not to exceed the maximum dollar amount of $250,000. Visit the Army SBIR web site for more information: [http://www.aro.army.mil/arowash/rt/](http://www.aro.army.mil/arowash/rt/).

The Army is committed to minimizing the funding gap between Phase I and Phase II activities. All Army Phase II proposals will receive expedited reviews and be eligible for interim funding (refer to Phase I Proposal Guidelines). Accordingly, all Army Phase II proposals, including Fast Track submissions, will be evaluated within a single two-tiered evaluation process and schedule. Phase II proposals will typically be submitted within 5 months from the scheduled DoD Phase I award date (the scheduled DoD award date for Phase I, subject to the Congressional Budget process, is 4 months from close of the DoD Solicitation). The Army typically funds a cost plus fixed fee Phase II award, but may award a firm fixed price contract at the discretion of the Contracting Officer.

Small businesses that received a non-selection letter may request a debriefing. The debriefing request must be made electronically within 30 days of notification of non-selection via the website provided in the non-select letter.
Key Dates

<table>
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<td>Phase I Evaluations</td>
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<td>November 2005*</td>
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*Subject to the Congressional Budget process.
+ Subject to change; Consult Army SBIR website http://www.aro.army.mil/arowash/rt/

Inquiries

Inquiries of a general nature should be addressed in writing to:

Susan Nichols  
Army SBIR Program Manager  
U.S. Army Research Office - Washington  
6000 6th Street, Suite 100  
Fort Belvoir, VA 22060-5608  
(703) 806-0980  
FAX: (703) 806-2046
<table>
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<tr>
<th>Research, Development &amp; Engineering CTR</th>
<th>POC</th>
<th>Phone</th>
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<tr>
<td>U.S. Army Materiel Command</td>
<td></td>
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<tr>
<td>Armaments RD&amp;E Center</td>
<td>Carol L'Hommedieu</td>
<td>(973) 724-4029</td>
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<td>Army Research Laboratory</td>
<td>Dean Hudson</td>
<td>(301) 394-4808</td>
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<td>Army Research Office</td>
<td>Dr. Roger Cannon</td>
<td>(919) 549-4278</td>
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<td>Aviation RD&amp;E Center</td>
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<td>(757) 878-5400</td>
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<td>Communications Electronics Research, Development &amp; Engineering Center</td>
<td>Suzanne Weeks</td>
<td>(732) 427-3275</td>
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<tr>
<td>Edgewood Chemical Biological Center</td>
<td>Ron Hinkle</td>
<td>(410) 436-2031</td>
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<tr>
<td>Missile RD&amp;E Center</td>
<td>Otho Thomas</td>
<td>(256) 842-9227</td>
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<tr>
<td>Natick Soldier Center</td>
<td>Dr. Gerald Raisanen</td>
<td>(508) 233-4223</td>
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<td>Simulation, Training and Technology Center</td>
<td>Mark McAuliffe</td>
<td>(407) 384-3929</td>
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<tr>
<td>Tank Automotive RD&amp;E Center</td>
<td>Alex Sandel</td>
<td>(810) 574-7545</td>
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<tr>
<td>U.S. Army Test and Evaluation Command</td>
<td>Curtis Cohen</td>
<td>(410) 278-1376</td>
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<td>Developmental Test Command</td>
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<tr>
<td>U.S. Army Corps of Engineers (Engineer Research Development Center)</td>
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<tr>
<td>HQ, Engineer Research &amp; Development Center</td>
<td>Theresa Salls</td>
<td>(703) 428-6255</td>
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<tr>
<td>Construction Engineering Research Lab</td>
<td>Anne Cox</td>
<td>(217) 373-6789 ext. 7311</td>
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<tr>
<td>Cold Regions Research and Engineering Lab</td>
<td>Theresa Salls</td>
<td>(703) 428-6255</td>
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<tr>
<td>Topographic Engineering Center</td>
<td>Charles McKenna</td>
<td>(703) 428-7133</td>
</tr>
<tr>
<td>Environmental Lab, Geotechnical &amp; Structures Lab, Information Technology Lab, and Coastal &amp; Hydraulics Lab</td>
<td>Steve Pranger or Milton Myers</td>
<td>(601) 634-3706, (601) 634-3376</td>
</tr>
<tr>
<td>Deputy Chief of Staff for Personnel (Army Research Institute)</td>
<td>Dr. Jonathan Kaplan</td>
<td>(703) 617-8828</td>
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<tr>
<td>U.S. Army Space and Missile Defense Command</td>
<td>Dimitrios Lianos</td>
<td>(256) 955-3223</td>
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<tr>
<td>U.S. Army Space and Missile Defense Command</td>
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<tr>
<td>Medical Research and Materiel Command</td>
<td>Terry McCune</td>
<td>(301) 619-2110</td>
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DEPARTMENT OF THE ARMY
PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets the Army SBIR requirements. **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 Cover Sheets along with the full Technical Proposal, Cost Proposal and Company Commercialization Report were submitted using the SBIR proposal submission system, which can be accessed via the Army’s SBIR Web Site (address: http://www.aro.army.mil/arowash/rt/) or directly at http://www.dodsbir.net/submission. The Proposal Cover Sheet clearly shows the proposal number assigned by the system to your proposal.

______ 2. The proposal addresses a Phase I effort (up to $70,000 with up to a six-month duration) AND (if applicable) an optional effort (up to $50,000 for an up to four-month period to provide interim Phase II funding).

______ 3. The proposal is limited to only ONE Army solicitation topic.

______ 4. The Project Summary on the Proposal Cover Sheet contains no proprietary information and is limited to the space provided.

______ 5. The Technical Content of the proposal, including the Option, includes the items identified in Section 3.4 of the solicitation.

______ 6. The Company Commercialization Report is submitted online in accordance with Section 3.4.n. This report is required even if the company has not received any SBIR funding. (This report does not count towards the 25-page limit)

______ 7. The proposal, including the Phase I Option (if applicable), is 25 pages or less in length. (Excluding the Company Commercialization Report.) Proposals in excess of this length will not be considered for review or award.

______ 8. The proposal contains no type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

______ 9. The Cost Proposal has been completed and submitted for both the Phase I and Phase I Option (if applicable) and the costs are shown separately. The Cost Proposal form on the Submission site has been filled in electronically. The total cost should match the amount on the cover pages.

______ 10. The entire proposal must be electronically submitted through the online submission site (http://www.dodsbir.net/submission) by 6 a.m. on August 12, 2004.

______ 11. If applicable, the Bio Hazard Material level has been identified in the technical proposal.
Army 04.3 Topic Index

**Armaments RD&E Center (ARDEC)**
A04-001  Rapid Q-Switching of Solid-State Lasers
A04-002  Frame Rate Hyperspectral Target Segmentation
A04-003  Innovative Mobile Extrusion Plant for Onsite Fabrication of Ammunition Packaging Materials from Composite Recycled Plastics
A04-004  Ballistically Projected Conducted Energy (Electric Stun) Projectile
A04-005  Adaptive Bandwidth High Power RF Antenna
A04-006  Lubrication Free Small Arms Weapons Coatings
A04-007  Targeting Image Sensor for Rapidly Spinning Projectiles
A04-008  Long Storage Life Active Battery
A04-009  Rifle Recoil Energy Reclamation Concepts
A04-010  Innovative Wall Penetration Munition
A04-011  Innovative Intelligent Agent and Cognitive Decision Aids Component Technology
A04-012  Novel High Strength, High Precision, High Ductility Warhead Case Material
A04-013  Novel Use of Magnesium Composites to Reduce Weight of Mortar Systems
A04-014  Innovative Modular Interlocking Pallet Containers
A04-015  Explosive Detection Device
A04-017  No-Preset Autonomous Proximity (NPAP) Fuzing-Med Cal Munitions
A04-018  Near-Vehicle Situational Awareness and Omnidirectional Weapons Detection System
A04-019  Innovative Wireless, Self-Mapping Small Baseline Acoustic Array
A04-020  Rapidly Emplaced Devices to Attach Sensors/Demolitions to Structures
A04-021  On-Board Recorder for Data Acquisition During Firing and Flight of Projectiles
A04-022  Mega-Volt X-Ray Digital Imaging Inspection System
A04-023  Microsystems Technology (MST) for Fuzing in Low-Spin/Low-G Launch Environment
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**Army Research Institute (ARI)**
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A04-028  Emotional Intelligence Tools for Personnel Selection, Training and Development
A04-029  Computer-Adaptive Assessment of Temperament to Support Personnel Selection and Classification Decisions
A04-030  Shared Understanding Across Levels of Command
A04-031  Trust in Temporary Groups
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**Army Research Lab (ARL)**
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A04-034  Multifunctional Ceramic Barrier Coatings for Si-Based Ceramic Components
A04-035  Integrated Multi-Channel MHz Speed Fiber Phase Shifters for Free-Space Laser Communication Transceiver Systems
A04-036  Radar Target Signature Modulator
A04-037  New Concepts and Tools for Unit Design and Evaluation
A04-038  Soldier Universal Robot Controller
A04-039  RF Unattended Ground Sensors (UGS) for Retargeting
A04-040  Innovative Gas Path Sealing Concepts for Improved Turbine Engine Performance
A04-041  Multipurpose Reactive Materials
A04-042  Blast Damage Analysis
A04-043  Manpower and Personnel Estimation Methods for Post-Deployment Software Maintenance
A04-044 Flexible Transparent Conducting Films
A04-045 Advanced Ultra Broad Band Direct Conversion Digital Receiver
A04-046 Development of Long Ceramic Tubes for Gun Barrel Applications
A04-047 Graphical/Visual Multiscale Model Builder & Data Structure
A04-048 InGaN Channel HEMTs for High-Frequency, High-Power Electronics
A04-049 Highly Efficient, Power-Scalable Long-Wavelength Diode Laser Pumps for Eye-Safe Solid-State LaserDevelopment
A04-050 Composite Proton Exchange Membranes for Multifunctional Power Generating Structures
A04-051 Development of an Unattended Ground Sensors (UGS) Dispenser for a Small Unmanned Ground Vehicle (SUGV)
A04-052 Advanced Metal-Air Batteries
A04-053 Controllable Direct Electrical Conversion of Isotopic Radiation
A04-054 Miniature Actuators for Small Arms Munition Control
A04-055 Command Decision Modeling in Distributed Combat Simulation
A04-056 Bio-Based Nano-Electronic, Electro-Optical, or Semiconducting Device Materials
A04-057 Signal Enhancement Technology for Advanced Microplasma-Based Force Protection Sensors
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A04-062 Solid Sorbent Trap for the Safe Handling of Chemical and Biological Contaminated Materials
A04-063 Identification and Characterization of Molecular Inhibitors of Cognitive Performance
A04-064 Anomaly and Fault Detection for Mobile Ad Hoc Communication System
A04-065 Innovative Hosts for Bacteriorhodopsin-Based Optical Memory
A04-066 Integration of Airborne Doppler Lidar Data into Real Time Analysis and Fusion of Battlefield Weather Conditions
A04-067 Bistable Lattice Composites for Armor
A04-068 ZnO Based Light Emitters for UV/Blue Applications
A04-069 Compact Alkaline Fuel Cell System
A04-070 Innovative Standoff Sensor Technology for Military Robotics Platforms
A04-071 Repair, Regeneration, and Differentiation in Humans
A04-072 An Atmospheric Surface Layer Profiler
A04-073 Visual Stoichiometry Breaking in Linear Response Chemical Test Strips
A04-074 Intelligent Force Management

Army Test & Evaluation Center (ATEC)
A04-075 Unmanned Aerial Vehicle (UAV) Close-Formation Control System (CFCS)
A04-076 Chemical Cloud Tracking Through Hyperspectral Imaging

Aviation RD&E Center (AVRDEC)
A04-077 Prognostic Wear Prediction Tool for BlackHawk Hanger Bearings
A04-078 Obstacle Display for Hover in Degraded Visual Environments
A04-079 Electromechanical Actuator Controller Technology
A04-080 Combat Rotorcraft EMI Suppression Technology (CREST)
A04-081 Automated Air Traffic Control (ATC)
A04-082 Advanced Flow Control Actuators for Fuselage Drag Reduction
A04-083 Advanced Stress Measurement Technologies for Small Turbine Engines
A04-084 Oil Free Couplings For High Speed Turboshaft Engines
A04-085 An Aerodynamic Tool for Rotorcraft Brownout Analysis
A04-086 Single Crystal Piezoelectric Actuators for Rotorcraft
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A04-089  Ducted Fan Model for Real-Time Rotorcraft Flight Simulation
A04-090  Flight Control System Using Secondary Systems (FUSS)
A04-091  Crashworthy Ballistic Tolerant Fuel Tank Weight Reduction
A04-092  Reconfigurable Multimodal Control Station (RMMCS) for UAV Control
A04-093  Modeling and Analysis of Rotor Blade Erosion Phenomena/Mechanisms

Communications Electronics Research, Development & Engineering Center (CERDEC)
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A04-096  Advanced Algorithms for Unmanned Systems Resource Optimization
A04-097  Self Contained Displacement or Velocity Sensor
A04-099  Integrated Biometrics for Handheld and Mobile Devices
A04-100  Information Distribution for Handheld and Mobile Devices
A04-101  Arabic to English Machine Translation System
A04-102  Full Color, Flexible, Day/Nighttime Displays for Mobile Battle Command Environments
A04-103  Handheld Positioning/Navigation System for Urban and Indoor Environments
A04-104  Co-Channel Interference Mitigation Test Apparatus
A04-105  An Ontologically-Based Data Fusion Model
A04-106  Integrated Wideband Signal Intelligence (SIGINT) Sensor
A04-107  JAVA Raw Socket and Network and Transportation Protocol Layer Application Programming Interface (API)
A04-108  Advanced Visualization Support of Higher-Level Fusion Processes
A04-109  Small Arms Fire and Alternative Missile Launch Detection
A04-110  Wideband Collection
A04-111  Commercial Radio Based Identification
A04-112  Ultra-Lightweight Moving Target Indicator (MTI) Radar for Unattended Ground Sensors (UGS) and Organic Aerial Vehicles (OAV)
A04-113  Wireless Local Area Network (LAN) Based Surveillance System
A04-114  Small, Low Cost, Long Wave Infrared (8.5-12 Micron) Semiconductor Laser for Military Platform and Perimeter Protection, Free Space Communications and Chemical Sensing
A04-115  Mobile Sensor Systems for Intelligence Collection Using Doppler Shifting of Existing Communication Technology
A04-116  Passive Low Light Level Solid State Silicon Imaging Camera Development
A04-117  Uncooled Midwave Focal Plane Array (FPA) and Camera for RPG Detection
A04-118  Acoustic Landmine Detection
A04-119  High Performance Longwave Infrared (LWIR) HgCdTe on Silicon
A04-120  Novel Hyperspectral Sensor Components
A04-121  Passive Ranging with Motion Detection
A04-122  Innovative 3-D Imaging for Uncooled and Low Light Level Sensors
A04-123  High Performance Low-Profile Wave-Guided Head Mounted Display
A04-124  False Alarm Mitigation and Highly Flexible Non-Parametric Decision for Airborne Minefield Detection
A04-125  Scene Based Non-Uniformity Correction For Infrared Focal Plane Arrays (IRFPAs)
A04-126  Automatic/Assisted Recognition of Human Intention and Human Group Activity Intention in IR Images
A04-127  Modeling and Simulation of Spectral and Spatial Efficiency, Communications Bandwidth and Range Optimization and Security Performance in a Directional Networked Communications Environment
A04-128  High Efficiency Monolithic Microwave Integrated Circuit (MMIC) Power Amplifiers For SATCOM
A04-129  Networked Micro-Radios for Micro-UAVs
A04-130  Laser Agile Multibeam Payload
A04-131  RF (Radio Frequency) Communications for Unattended Ground Sensor and Munition Systems
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A04-133  Superconductor Technology for SATCOM Applications
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A04-135  Subterranean Communications for First Responders and the Military
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A04-137  Network Scalability and Performance Analysis Topic **TopicCanceled**
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A04-139  Biobatteries

**Edgewood Chemical Biological Center (ECBC)**
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A04-141  Ultra-Compact Carbon Dioxide Laser For Chemical Sensor

**Engineer Research & Development Center (ERDC)**
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A04-143  Self-Calibrating, Self Locating Seismic-Acoustic Sensor System
A04-144  Self-Powered Sensors for Structural Assessment of Bridges
A04-145  Course-of-Action Forecasting
A04-146  Detector Array for Aerosol Particles
A04-147  Biological Warfare Agent (BWA) Countermeasures in Heating, Ventilation, and Air Conditioning (HVAC) Systems of Army Installation Buildings
A04-148  Remote Acoustical Reconstruction of Cave and Pipe Geometries
A04-149  Electrokinetic Soil Stabilization for Rapid Construction
A04-150  Electrokinetic Generation of Biocides for Advanced Air and Water Filtration to Mitigate Biological Threats
A04-151  GeoText
A04-152  Soil Imaging System
A04-153  Scalable Wireless Geo-Telemetry Capability for Miniature Smart Sensors

**Missile RD&E Center (MRDEC)**
A04-154  Guidance Technique for a Low-Cost Kinetic Energy Interceptor
A04-155  Low Cost Adaptive/Programmable Waveform Generator
A04-156  On-Demand Gas Generator with Real-Time, Open-Loop Control System for Gel Propulsion
A04-157  Protective Coating for ZnS Windows & Domes
A04-158  Unmanned Air Vehicles Diagnostics/Prognostics
A04-159  Innovative and Cost Effective Obstacle Avoidance/Navigation for Small Tactical Unmanned Aerial Vehicles (UAVs)
A04-160  Innovative Software Anti-Tamper Techniques
A04-161  Stabilization Technology/Techniques for use with Commercial Uncooled Infrared Technology
A04-162  Advanced Rendering Algorithms for Real-Time Physics-Based Sensor Scene Generation
A04-163  Energy Harvesting for Missile Health Monitoring
A04-164  Corrosion Sensors for Army Missile Systems and Aircraft Applications
A04-165  Integration of Multiple Models and MEMS Data into Computer Algorithms for Safe/Shelf Life Prediction of Rocket Motors
A04-166  Infrared Seeker Algorithm Evaluation Testbed
A04-167  Low-Cost, Large-Area Conformal Detector Arrays
A04-168  Non-Intrusive Measurement Techniques for Scramjet Ground Test Environments
A04-169  Innovative Hardware Anti-Tamper Techniques
A04-170  Consolidation of Nanograin Ceramics
A04-171  High Strength Nanomaterials Fiber for Lightweight Composite Missile Cases
A04-172  Affordable Efficiency Improvements for Small Turbine Based Flight Engines
A04-173  Alternate Scramjet Fuel Modeling and Evaluation
A04-174  An Integrated Thrust Control Solution
A04-175  Development of a Highly Integrated Multifunctional Optical Sensor for Monitoring Weapons Health and Battlefield Environments
A04-176  Strategically Tuned Absolutely Resilient Structures
Medical Research and Materiel Command (MRMC)
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.

A04-177  Field Deployable Diagnostic Test for Active Cutaneous Leishmania and a Test for Latent
Infection
A04-178  Development of an Intracavitary Hemostatic Agent for Use in Noncompressible Hemorrhage
A04-179  Human Biomonitoring Device for Military-Relevant Chemical Exposures
A04-180  Developing a Catalytic Bioscavenger for Organophosphorus Nerve Agents
A04-181  Nonviral Gene Therapy
A04-182  Medical Simulation Training for First Response to Chemical, Biological, Radiological, Nuclear
Events
A04-183  Broad-spectrum Prophylaxis for Infectious Diarrhea in Deployed Military Forces
A04-184  Hemorrhage Control for Non-Compressible Extremity Injuries
A04-185  Automated Interactive Coping Skill and Resiliency Tool
A04-186  Development of a Viral Based Gene Delivery System for Chemical Agent Bioscavengers and
Biological Agent Vaccines
A04-187  Developing Nanotechnologies for Detection and/or Targeted Treatment
A04-188  Fatigue and Performance Modeling of Sleep-Deprived Soldiers
A04-189  High Throughput Genomics Screening for Malaria Antigen Discovery
A04-190  Antimicrobial Bone Graft Substitute
A04-191  Soldier Mounted Eye Monitor
A04-192  Novel Protein Nanodelivery Systems for Biological Agent Countermeasures
A04-193  Simulation-Based Open Surgery Training System (SOSTS)
A04-194  Development of High Throughput Bioassays to Identify Correlates of Protective Immunity
Against Malaria
A04-195  Ballistic Protection for Army Aviation Helmets
A04-196  A Homologous Non-Human Primate Model System for Producing and Testing Recombinant
Human Compatible Serum Butyrylcholinesterase
A04-197  Smart Devices/Instruments For a Sophisticated OR Environment
A04-198  High-Throughput Proteomics Strategy for Detection and Identification of Biomarkers of Malaria
Exposure
A04-199  An Active Noise Reduction Communication Earplug for Helicopter Crew
A04-200  Volume Conduction Invasive Medical Data Communication System
A04-201  Novel Routes of Drug Administration to Enhance Compliance in Soldiers

Natick Soldier Center (NSC)
A04-202  Metabolic Engineering for Performance Enhancement
A04-203  Miniature, Low Cost Real-Time Weather Sensor for Airdrop
A04-204  High Performance Rechargeable Conformal Battery
A04-205  Smart Terrain for Autonomous Agent Applications
A04-206  Detection of Protease Activity for the Identification of Biological Toxins and Exposure to
Chemical Warfare Agents
A04-207  Solar Cogeneration of Electricity and Heat for Field Kitchens
A04-208  Variable Glide Aerial Delivery Parachute Systems
A04-209  Design, Synthesis and Preparation of New Azobenzene Materials for Use in Broadband Laser Eye
and Sensor Protection
A04-210  Solar Refrigeration
A04-211  Onsite Field-Feeding Waste to Energy Converter
A04-212  Shelter Fabric and Soldier Uniform Textile-Mounted Electronic Displays for Military Command Functions
A04-213  Low Drag, Low Cost Suspension Line Technology for Parachutes
A04-214  High Efficiency Shelter Lighting Utilizing Solid State Illumination Technology
A04-215  Novel Conductive Fibers for Multi-Path Power/Data Transfer Embedded in Textile Substrates of Warrior Clothing & Equipment
A04-216  Computer Input Devices and Embedded Sensors in Future Warrior Handwear (Gloves)
A04-217  Anti-Personnel Blast Mine Protection

**Space and Missile Defense Command (SMDC)**
A04-218  Enhanced Lethality Munitions for Army Applications
A04-219  Advanced Guidance, Navigation and Control (GNC) Algorithm Development to Enhance the Lethality of Interceptors Against Maneuvering Targets
A04-220  Passive, Active Stokes Polarization Imaging System
A04-221  High Power Microwaves

**Simulation, Training & Technology Center (STTC)**
A04-222  Low Cost Wide Field of View Head Mounted Display for Aviation Training
A04-223  Distributed and Collaborative Information Environment for Embedded After Action Review Technologies
A04-224  Visual Aid for Multi Resolution Federation Planning and Development
A04-225  Innovative Concepts for Low-Cost Multi-Spectral Targets for Gunnery Training
A04-226  Intelligent Agents for Real-Time Story Adaptation for Training Assessment
A04-227  Innovative Wireless Network Modeling And Simulation Technology In Support of Training, Testing And Range Instrumentation Requirements

**Tank Automotive RD&E Center (TARDEC)**
A04-228  Continuous Dynamic Processing of Ceramic Tiles for Ground Vehicle Protection
A04-229  Automated Propagation of Design Intent from Legacy Drawings to 3D Models
A04-230  Optically Clear Armor Protection
A04-231  Composite Structures for Ballistic Protection
A04-232  Polarimetric Sensors for Robotic Vehicle Perception
A04-233  MEMs Based Micro Technology Engine Management/Health Monitoring System
A04-234  Standoff Improvised Explosive Device (IED) Detection System
A04-235  MEMS Testing Simulator
A04-236  Sensor Technology for Materials Characterization aboard the Mobile Parts Hospital
A04-237  Development of Blast Event Simulation
A04-238  Visualization Tool for Animating Combined Multibody Dynamics and Computational Fluid Dynamics Simulations
A04-239  Multi-Resolution Modeling of Ground Platform Dynamic Performance and Mobility
A04-240  High-Power, High-Voltage, Bidirectional DC-DC Converter
A04-241  High Power Density, High Torque Density, Efficient Electric Motors and Generators
A04-242  Filtration and Enhanced Sensor Technology (FEST)
A04-243  Design of New Technology Final Drives for 21st Century Military Vehicles
A04-244  Advanced Suspension Characterization Test Fixture
A04-245  Advanced Military Fuel Cell Applications
A04-246  Development of a Characterization Test System for Powertrains of Military Vehicles
A04-247  Complex Electronics Packaging Thermal/Signature Management Design Tool
A04-248  Cooling Objectives and Operative Leverage (COOL) Techniques
A04-249  Advanced Military Hybrid Technology
A04-250  Development of Endurable Thermal Barrier Coatings for Diesel Engine Specific Heat Reduction
A04-251  Modular Generic Voltage Converters
A04-252  Hands-Free Tele-Operation Via Physiological Signal Recognition
A04-253  Fuel Lubricity Evaluator Sensitive to Additives
A04-254  Preservative/Break-in Lubricating Oil
| A04-255 | Assured Operational Mobility Across Gaps for the Future Combat Systems/Future Force) FCS/FF |
| A04-256 | Multi-Power Source for MEMS Packaging |
| A04-257 | Advanced Military Trailer Technology |
| A04-258 | Enhanced Access Control within a Pervasive Computing (PvC) Environment |
| A04-259 | Tactical Biorefineries |
A04-001  TITLE: Rapid Q-Switching of Solid-State Lasers

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: PEO Soldier and PEO Ammunition

OBJECTIVE: Improve the Repetition rate of a Q-Switched Solid-State Laser without degrading performance (energy/pulse). Rep rates of greater than 1 kHz are desired. Develop and demonstrate an innovative switching technique that will provide a way to modulate that frequency as well as the time between pulses in a burst mode of operation.

DESCRIPTION: Significantly higher peak power outputs are achieved in LASER systems by a method known as Q-switching. For future Army applications, the pulse rate of a Laser system needs to be in the 1 kHz to 100 kHz range. Also desirable is the ability to change that repetition rate, as well as the ability to determine the time between pulses. In some situations, it is desirable to operate the device only a few times per second, but with a very rigid time between pulses that may be less than the standard operating frequency. Current experimentation is determining the optimum time between high energy solid state laser pulses for a variety of effects. Depending on range to target and target type, the elapsed time between pulses can vary from 10s of microseconds to 10s of milliseconds. Regardless of the length of time between the pulses, the energy therein must remain constant. This effort is to develop and demonstrate a very high, and variable, repetition rate Q-Switch for these applications.

PHASE I: Research and understand the Q-switching methodology currently used. Determine what components thereof are open to modification that would ultimately result in the above listed desired characteristics. Laser source is up to the proposing contractor, but the technology cannot be limited to one type of laser. It must be designed with a solid-state laser as the primary source. Critical technology path must be defined by the end of the Phase I effort. Provide preliminary design details and expected operational conditions for proposed solution.

PHASE II: Build prototype device utilizing candidate technology and demonstrate high rep rate without significant degradation in energy per pulse. Prototype will be provided to Army for further evaluation.

PHASE III DUAL-USE APPLICATIONS: Applications include US Military, but also stretch into the Q-switching realm of medical operations, and metal cutting.

REFERENCES:
1) http://en2.wikipedia.org/wiki/Q-switching
2) http://www.repairfaq.org/sam/laserioi.htm#ioilpap1

KEYWORDS: Laser, solid-state, Q-switching, short pulse laser, pulse

A04-002  TITLE: Frame Rate Hyperspectral Target Segmentation

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Close Combat Systems and PM Soldier Weapons

OBJECTIVE: Develop innovative fast algorithms and a platform suitable for frame-rate target/background segmentation of hyperspectral imagery.

DESCRIPTION: Hyperspectral image segmentation technology, developed over the past several decades in support of satellite-based earth resource assessment and of various military target recognition applications, does not satisfactorily address some emerging application opportunities. This technology arises as a special case of the more
general pattern recognition problem, in which various measured image features are used to assign whole images or regions within images to one of several possible classes on the basis of distance or likelihood functions. An application of interest to the Army involves ground-based reflective hyperspectral imagery. In this application, constantly-shifting celestial, atmospheric, and reflective illumination components greatly complicate reliable segmentation. Additionally, this application ultimately requires frame-rate throughput implemented in micro size hardware - a requirement that is not easily satisfied with existing hardware and algorithms. This solicitation is for the development of self-training segmentation algorithms that reliably classify pixels in the Army’s ground-based reflective hyperspectral image as either background (expected) or non-background. The algorithm(s) should accommodate implementation on fast micro hardware architectures. Proposals must demonstrate in-depth comprehension of the issues surrounding ground-based hyperspectral image segmentation, as well as those involved in fast implementation.

PHASE I: To demonstrate an understanding of and to further study the effects of shifting celestial, atmospheric, and reflective illumination, simulate multiple synthetic data cubes adding the effects in some logical order. Propose for Phase II implementation several candidate algorithms for segmentation that have a high probability of success based on the simulation study. Present a design for frame-rate (>20 data cubes per second) implementation of the algorithm(s).

PHASE II: Using simulated and real hyperspectral data cubes whose size is greater than 512 x 512 x 64 colors x 12 bits, implement segmentation (spectral and spatial) algorithms determining their relative success and throughput. Continue the study determining optimal algorithms and those that also require the least number of spectral bands, for acceptable-reliable fast segmentation. Implement on a small platform, preferably less than 2 cubic inches (not including power supply), the algorithm/s that successfully segment imagery at frame rates. Test and demonstrate frame-rate operation.

PHASE III DUAL USE APPLICATIONS: Military applications include numerous target acquisition applications, including warrior scopes, UAV platforms, etc. Commercial applications include surveillance cameras for homeland security and other surveillance missions.

REFERENCES:
1) http://www.rsinc.com/envi/Hyperspectral.asp
2) http://www.techexpo.com/WWW/opto-knowledge/

KEYWORDS: hyperspectral classification, target recognition, surveillance, video surveillance, tracking, vision system, pattern analysis

A04-003 TITLE: Innovative Mobile Extrusion Plant for Onsite Fabrication of Ammunition Packaging Materials from Composite Recycled Plastics

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and develop a mobile fabrication plant that will extrude dimensional lumber and pipe cross sections of any required size and length from recycled plastics composite materials. Such material will then be usable to build ammunition packaging and dunnage, pallets, retrograde boxes, shelving and racks inside containers, concrete forms, temporary and permanent structures, furnishings for offices and quarters, fluid transfer systems, water and sewer systems, oil pipelines, etc. Pipes can be extruded in exact sizes to help package individual rounds for retrograde or repack captured enemy ammo, build and repair or replace plumbing systems damaged by battle events. Extrusion plants exist but none have been designed to be mobile. The research and development effort would be directed at identifying types of battlefield materials applicable for recycling into other useful products, the design of new extrusion dies that could be readily changed to extrude a different size of stock material and at developing a smaller and lighter extrusion head than currently in use today.
DESCRIPTION: Dimensional lumber and plastic pipe products have been available in the commercial sector for many years. Although dimensional lumber products have traditionally been withheld from load bearing assemblies, new advances in these products make them more suitable for such uses. Plastic piping has become a more common place due to its ease of installation and maintenance. An average ammunition ISO shipping container uses approximately 500 pounds of lumber for bracing. This material is often procured locally or shipped from the United States, cut to size and reshipped back to the US for depot storage. The objective is to alleviate expenses by providing a mobile extrusion plant that can extrude usable products in the exact sizes needed and in the required lengths from a hopper full of composite material pellets made of recycled plastics and additional filler materials. The extrusion plant would be used on site and the consumable plastic pellets would be the item in the supply stream. Since it would be shipped in bulk quantities the cubic space would be maximized for efficiency and the varieties of product in the supply pipeline would be reduced from “every size of lumber and pipe known” to “plastic pellets in a crate.”

PHASE I: Investigate the existing plastic building materials manufacturing processes and machinery to identify items that could be readily adopted for this use, or that could be modified or redesigned by the equipment manufacturer for this use. Identify battlefield debris that can be processed into feedstock for reprocessing.

PHASE II: Fabricate and characterize a prototype mobile extrusion system that produces lumber and pipe products suitable for use by ammunition managers and handlers, army engineers, and any other parties with a use for lumber at the end of the supply pipeline.

PHASE III DUAL USE APPLICATIONS: A number of civil agencies and remote engineering operations such as oil well construction and management, mining, etc, may find a use for this technology when working in parts of the world where lumber is scarce and the need is urgent.

REFERENCES:
1) http://www.plasticlumber.com/
2) http://www.usplasticlumber.com/
3) http://www.plasticlumberyard.com/
4) http://www.plasticlumberdepot.com/
5) http://www.plasticlumber.org/srplpdfs/srpl01.pdf
7) http://www.everlastlumber.com/
8) http://www.aeo1.com/
9) http://www.cierraindustries.com/plasticlumber.asp
10) http://www.btbnetsolutions.com/MachineryData/PlasticConsultantsandMachineryConsultants.htm

KEYWORDS: Plastic, composite materials, ammunition, logistics, supply pipeline, dimensional lumber, extruded pipe, remote construction sites

A04-004 TITLE: Ballistically Projected Conducted Energy (Electric Stun) Projectile

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

ACQUISITION PROGRAM: PEO Soldier and PEO Ammunition

OBJECTIVE: To design, build and launch a projectile that would deliver electrical energy to the target in order to incapacitate the target in a non-lethal manner.

DESCRIPTION: With the use of electrical energy to incapacitate individuals one can expect to have a greater effective range using a blunt trauma projectile. When the projectile loses effective velocity, it is hoped that the use
of stored electrical energy can still have an effect against an individual when it impacts against that individual. The end result would be a blunt trauma round that would be more effective out to a farther range. The projectile would derive its electrical energy from launch using conventional propellant or through the use of energy storage or generation within the projectile. The projectile would not be tethered to the launching platform as in current versions of electrical incapacitation devices. Innovation is encouraged in how to store, generate, deliver, and vary the electrical energy to the target. The preferred launch platform is the 40mm M203 grenade launcher but other standard platforms (e.g., 12 gauge shotgun, etc.) will be considered.

PHASE I: Research and design a proof-of-principle model that would be able to deliver electrical energy rapidly to a target individual in a non-lethal manner. Show the basic method of energy storage and/or generation, and method of delivery.

PHASE II: Develop and build a prototype device, demonstrating its effectiveness from 6m to 80m. The device would be self-contained and not tethered to the launching platform. The launching platform would be a 40mm M203 grenade launcher or a 12 gauge shotgun.

PHASE III DUAL USE APPLICATIONS: With the development of a non-lethal munition, the device could be used by military (active and national guard), law enforcement, and homeland security agencies. Also, novel approaches to energy generation and storage can be applied in the area of dynamic controls.

REFERENCES:

KEYWORDS: Electric stun, Electro-muscular Disruption, Taser, Non-Lethal, Less-than-Lethal

A04-005 TITLE: Adaptive Bandwidth High Power RF Antenna

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: An innovative antenna design which stresses high bandwidths, high gain, high power, and small compact size for operation on vehicles or fixed sites with operational parameters as described below.

DESCRIPTION: There is a requirement for a high power, high gain, and wide bandwidth antenna for operation at HF/VHF and another similar antenna for VHF/UHF frequencies. The objective is the development of an antenna which has a minimum gain of 12 dBi over as wide a frequency band at HF/VHF (maximum size of 2 meters in diameter and 3 meters in length) and another similar antenna at VHF/UHF (maximum size of 1.2 meters in diameter and 2 meters long). Both antennas must be capable of handling well over 300 kilowatts at a 50% duty cycle.

PHASE I: Develop a theoretical model of an antenna capable of optimum performance for wide bandwidth and gain as discussed and predict the performance and high power handling capability. Two antennas are required: one at HF/VHF and another at VHF/UHF. Development and test of breadboard models of the innovative antennas are encouraged but not necessary. Document the design and predicted performance.

PHASE II: Construct and deliver a prototype of an antenna based on the designs of the Phase 1 program. Tests should be done in an environment emulating the intended applications of the antenna. Complete a final report showing the results and comparisons to the theoretical models and latest state-of-the-art antennas.

PHASE III, DUAL-USE APPLICATIONS: This innovative antenna, being smaller and covering wider bandwidths that those available will find communications applications in commercial airliners, Coast Guard ships, aircraft, and helicopters. Other applications are vehicular and personal communications and navigation applications. Its high
power capability will find applications for low frequency radars and frequency hopping wide band applications. For production military applications it will include high power jamming systems and broadband frequency hopping radars.

REFERENCES:

KEYWORDS: Antenna, RF, High Power Microwave, UHF, VHF, Antenna Design

A04-006 TITLE: Lubrication Free Small Arms Weapons Coatings

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

ACQUISITION PROGRAM: PM Individual Weapons and PM Soldier Weapons

OBJECTIVE: Determine the feasibility of an innovative protective coating for critical weapon/vehicle components to eliminate the need for other coatings such as chrome plating, phosphate, anodize, carburize, nitride, organic matte and wet lubrication. Develop the coating and demonstrate the ability to apply the developed coating on a specific weapon (M-16/M4, or M-249) on all its metallic surfaces except the tube bore and demonstrate the ability to be able to fire/use the coated weapon without lubrication reliably under adverse conditions to include sand, dust, hot, cold and rain.

DESCRIPTION: Recent deployments have indicated the need to examine the manner in which weapons parts maintain their lubricity, particularly under sandy or dirty conditions. The ideal solution would be the application of some universal coating that would enhance part durability and eliminate the need for any wet lubrication under a variety of environmental conditions. The coating would ideally replace chrome plating, phosphate coating, anodizing and organic matte coating of selected parts. Evaluation factors for consideration would be that the coating would have a coefficient of friction approaching that of lubricated chrome plated metals, with some corrosion resistance, sliding wear resistance, abrasive wear resistance, and with a durable bond to the substrate weapon metal. It is proposed that corrosion resistance testing would be under either ASTM B117 or ASTM G85. It is proposed that the environmental engineering considerations for the coating would be tested per MIL-STD-810F. Ideally, the byproduct of the process would be basically steam, with no known pollutants associated with either the chemicals used in application or the process. Therefore, an added benefit of this activity would be the reduction or elimination of chrome plating and associated pollution issues. A coating such as this would represent a revolutionary breakthrough in coating technology that would allow small arms weapon manufacturers to eliminate their chrome plating facilities (and the associated pollution concerns associated with that process) while providing a unique coating that is equal in or potentially more wear resistant and more lubricious than chrome, anodize or phosphate coatings, while maintaining sufficient corrosion resistance to the protected substrate metal. The material deposition achieved should create a substantial bond between the substrate and the coating that can provide the life necessary to compete with current coatings. The resultant end product would be a weapon that requires no lubrication, with reduced schedules for cleaning, thereby mitigating one of the most significant recent user issues with small arms in general; the inability to keep weapons clean due to sand and dirt creating a gritty coating when mixed with lubricating oil. Additionally, all DOD services ground, air and sea vehicles that use lubrication systems may have similar uses for coatings of this sort to provide the capability to continue operations in the event of their lubrication system failure.

PHASE I: Demonstrate the feasibility of an innovative protective coating technology for small caliber weapon systems that can enhance part durability and eliminate the need for any wet lubrication under a variety of environmental conditions. Demonstrate deposition uniformity and coating effectiveness on either government-supplied weapons parts or metal coupons in limited environmental, functional and wear testing. Coating requirements will match those called out in the package for Special Operations Forces Combat Assault Rifle (SCAR), care of the US Army Special Operations Command (SOCOM), and all tests will be geared against those requirements.
PHASE II: Fully develop and characterize the coating on either government-supplied weapons parts or metal coupons. Tests should include an independent determination of the coating coefficient of friction (unlubricated), initial corrosion testing per ASTM B117 or ASTM G85, sliding wear life testing, abrasive wear life testing and environmental testing per MIL-STD-810F. Demonstrate a small caliber weapon system optimizing the innovative coating process for each specific metal part of the weapon system (e.g., ideal coating thickness and/or composition for each part based on the function of the specific part, base material and previous coating thickness). Strip all previous coatings from the weapon parts and recoat with the newly developed coating(s). Conduct physical chemical testing of each part, and conduct adequate firing/functional testing of the entire system to verify application and functional performance under a variety of test environments.

PHASE III DUAL USE APPLICATIONS: If successful, this process would have a wide variety of potential applications in almost any weapon system, vehicle or ancillary equipment that is subject to potential degradation due to the affects of an adverse environment or a lubrication system failure. It would be applicable to any surface that is not a tube bore on virtually all end items with steel or aluminum components during this phase and efforts to incorporate this process into other end items would commence during this phase. Dual-use would be sought in other DOD applications (Helicopter moving parts, swash plate, blade protection strip coating), marine (Propeller coating), manufacturing (sliding or rotating parts), aerospace (flap track coating), jet engine (Blisk coating) and automotive (Sliding or rotating engine parts) industries via the Coatings Implementation Integrated Process Team activities. The elimination of machine failure due to particulate build up in gummy liquid lubricant or failure due to lubrication system failure should prove advantageous in many different sliding wear applications.

REFERENCES:
1. Requirements Package for Special Operations Forces Combat Assault Rifle (SCAR), care of SOCOM, (Reference SOCOM Liaison Officer, Major Kevin Stoddard, kstodd@pica.army.mil)
2. Boron Nickel. Autocatalytic technology for new applications and as a suitable replacement for hard chrome, J. R. House (Surface Engineering Consulting Ltd), (12 GB file, available from: agoetz@pica.army.mil)
3. Tech Notes, Wynn Atterbury, (24 kb file, available from agoetz@pica.army.mil)

KEYWORDS: Weapons, Air, Ground and Sea Vehicles, Coatings, Sliding Wear, Abrasive Wear, Low Coefficient of Friction, chrome plating, phosphate, anodize, carburize, nitride, and wet lubrication

A04-007 TITLE: Targeting Image Sensor for Rapidly Spinning Projectiles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Weapons

ACQUISITION PROGRAM: PEO Soldier and PEO Ammunition

OBJECTIVE: Design a targeting image sensor that can be incorporated into a rapidly spinning projectile. The shooter will acquire a target through an electronic targeting mechanism and transmit the target image information to the projectile. The projectile will then home in on the “picture” of the target. The sensor must be inexpensive, capable of withstanding gun launch environments, and compact enough to fit in a 20 mm or smaller diameter projectile.

DESCRIPTION: There are current efforts to develop smart medium caliber weapon systems. These systems typically contain a sensor in the projectile that is sensitive to IR, laser or other energy sources. Once fired, the projectile locks on to the energy source and uses it to guide to the target. In most cases, this method requires a soldier to designate the target, this exposes the soldier to counter-fire. A fire and forget technique is desired that would be permit the soldier to designate, fire and move to the next target or firing position. Weapon sensors are
currently available that are capable of detecting a specific portion of the image presented to the shooter by his sighting mechanism. These sensors will allow the shooter to lock on a specific target that is within the shooters field of view. This effort would utilize the digital information from the sighting mechanism to program the projectile so that it will follow this target image to the actual target. The current technology can be applied to slowly spinning, fin stabilized, projectiles but is much more difficult to integrate into rapidly spinning, spin stabilized projectiles that must also withstand high g-load accelerations. This sensor could be a combination of IR, video or laser technologies as determined though the design phase. In the past, this concept was not technically feasible due to deficiencies in the then current sensors and signal processing techniques. Microprocessors and sensors are now available with the speed, size and capacity to perform the sensing and calculating functions that are required to process the volume of information generated by the spinning projectile. The sensor must be designed to function at a minimum of 1,000 revolutions per second while withstanding a minimum of 50,000 gee's of acceleration.

PHASE I: Develop an overall system design in block-diagram form that includes: sensor design, sensor technology, sensor specifications, microprocessor specifications and required computer algorithms.

PHASE II: Fabricate a prototype sensor package, to include hardware, software. Demonstrate proof-of-principle of the design by spinning the sensor at a minimum of 1000 revolutions per second while tracking a selected target as the target is moved within the field of view of the shooter. Develop and demonstrate the prototype system in a realistic environment with Army-supplied samples of archival and real-time video imagery. Conduct testing to provide feasibility over extended operating conditions. The sensor package must be capable of withstand a minimum of 50,000 gee's and perform at a velocity of 1000 meters per second.

PHASE III DUAL USE APPLICATIONS: This system would have utility in domestic policing applications where precise engagement of targets is required, such as SWAT teams. It could also be utilized for precise placement of sensors by other governmental agencies.

REFERENCES:
1) http://www.army-technology.com/contractors/missiles/oerlikon/
3) http://wwwdesignation-systems.net/dusrm/app4/ergm.html

KEYWORDS: Sensors, projectiles

A04-008 TITLE: Long Storage Life Active Battery

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

ACQUISITION PROGRAM: PEO Ammo and PEO Soldier

OBJECTIVE: Develop long storage life electrochemical systems that could be an alternative to custom specialty reserve batteries.

DESCRIPTION: Most conventional munitions utilize expensive reserve power sources that have long shelf lives and can be activated upon launch of the munition. Replacing these type of reserve electrochemical power source configurations with alternate or active configurations will yield energy and power densities greater than those of present power sources for munitions because active systems can take advantage of greater volume efficiency. Reserve power systems utilize large volumes to isolate electrolyte during storage and contain other components needed for the activation mechanism, active power systems do not. Also, because there are many more producers of active batteries than reserve batteries, the commercial market can be leveraged to produce active systems for munitions at a lower cost than reserve systems. This effort would focus on chemistries and constructions that would extend storage lives of active batteries out to 20 years and beyond.

PHASE I: Demonstrate laboratory battery cells with active battery technology that meet these goals:
Identify factors limiting power source life and performance, especially at -46°C. Propose methods (chemical and physical modifications) of minimizing these factors.

PHASE II: Starting with Phase I results, build cells incorporating improvements and package these cells to meet the following:
- Maximum Diameter: 5.6 mm
- Maximum Height: 5.5 mm
- Desired Voltage: 3.6 to 4.2 V
- Acceptable Voltage: 3.6 to 7.0 V
- Shock Survivability: 30,000 “g” in any direction
- Storage Temperature: -54°C to 74°C
- Operating Temperature: -46°C to 63°C
- Power Density: 25 W/l
- Energy Density after 20 years storage at 63°C: 0.75 Wh/l
- Maximum Time to return to at least 3.6 V under 14 kΩ load: 60 sec

Identify a protocol and demonstrate 20 year storage life at storage temperature extremes.

PHASE III DUAL USE APPLICATIONS: Military applications would include small, smart munitions such as submunitions and grenades, especially to power self-destruct function. Such power sources might also have utility for system monitoring of missiles and bombs during stockpile storage. Improvements made in the storage life of active power sources will have great application in a broad variety of consumer products that utilize commercial batteries. They should be especially attractive for applications with long standby times, such as alarm systems, emergency lighting, watches, etc., and would decrease the labor, cost and frequency of changing out these batteries.

REFERENCES:
http://www.rayovac.com/busoem/oem/research/lith_cells.shtml

KEYWORDS: active battery, shelf life, storage life, energy density, power density, self discharge
A04-009  TITLE: Rifle Recoil Energy Reclamation Concepts

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

ACQUISITION PROGRAM: PEO Solidier

OBJECTIVE: To design and develop a device(s) to reclaim some of the residual recoil energy that is used in the rifle when firing a projectile.

DESCRIPTION: Many of the devices that the soldier uses in the field are operated with batteries which can add to the overall weight that the soldier has to carry. The proposed work intends to address this issue by reclaiming some of the residual recoil energy used in the firing of the soldier’s rifle and using it to run peripheral systems or to recharge some of the batteries that the soldier uses for other devices. There are several approaches that can be used in order to capture and recover the residual energy that is used when the M16 or M4 are fired.

PHASE I: Design a proof-of-principle device capable of demonstrating residual recoil energy reclamation device while using 5.56mm blank cartridges.

PHASE II: Develop and demonstrate a prototype device using a standard or slightly modified M16 or M4 rifle and demonstrate an energy storage system that can be used for other power systems such as computer device, flashlights, night-vision equipment and other battery using devices.

PHASE III DUAL USE APPLICATIONS: With the development of this system, it will have applications to other power management systems in the armed services and in the private sector. The basic research could be applied to other devices in order recover energy and make the systems more energy efficient.

REFERENCES:

KEYWORDS: M16A2, M4, 5.56mm, Recoil Energy

A04-010  TITLE: Innovative Wall Penetration Munition

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

ACQUISITION PROGRAM: PEO Ammunition and PM Soldier Weapons

OBJECTIVE: To design and prototype a small munition that would be able to penetrate through an 8 inch concrete wall and deliver a small explosive or non-lethal stun device into an interior space. Ideally this munition would be a 40mm grenade type munition delivered from an M203 launcher mounted underneath the standard M16 rifle. If the candidate technology or delivery system does not lend itself to integration into the M203 delivery system, the system must self-contained, consisting of the munition and a disposable launcher. For an M203 deliverable system, maximum weight of each round is 0.5 kg. For a self-contained delivery system, maximum weight per round is 2.0 kg.

Performance characteristics are as follows:
- Minimum arming distance for all fire condition is 25 meters.
- Minimum acceptable Maximum effective range is 250 meters.
- Maintain a relatively “flat” trajectory…dropping no more then 1 meter for every 100 meters traveled.
DESCRIPTION: In MOUT warfare, many situations call for neutralizing enemy combatants that would be using a building as defilade from allied direct fire. The objective of this munition is to be able to go through a concrete wall into the inside of the building in order to deliver a munition payload to the enemy taking cover inside. There are some situations where there are no windows or openings to lob a grenade into in order to neutralize the enemy. It is also an objective to be able to insert a non-lethal munition into a sealed room in order to subdue the enemy without great loss of life.

PHASE I: Design a proof-of-principle device. Demonstrate proof-of-principle by penetrating 8 inches of standard concrete or brick and mortar wall.

PHASE II: Develop and demonstrate a prototype device that delivers a munition to the interior space. Demonstrate the delivery of a non-lethal munition to the interior as well.

PHASE III DUAL-USE APPLICATIONS: With the development of a non-lethal munition, the device could be used by law enforcement in order to subdue suspects that are inside a building and where entering the building might be considered too dangerous.

REFERENCES:
1) http://stinet.dtic.mil/report ADA380848: Shock-Induced Damage in Rock and Concrete; Authors: Liu, Charles C.; Ahrens, Thomas J.
2) http://www.tpub.com/content/USMC/mcwp3353/css/mcwp3353_246.htm

KEYWORDS: wall breaching, urban warfare

A04-011 TITLE: Innovative Intelligent Agent and Cognitive Decision Aids Component Technology

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop real time intelligent agent based algorithms, design methodology and development tools to support rapid prototyping, implementation, integration and testing of reusable, adaptable and scalable embedded decision aids components that will provide the basis for developing the next generation of intelligent, network centric fires management, execution and control software for Future Combat System and Objective Force Warrior applications.

DESCRIPTION: Rapid advances in soft computing, agent software, artificial intelligence, cognitive science, information processing, distributed processing and software engineering technologies now make possible the automation and intelligent aiding of many time critical and mission critical combat tasks which the mounted and dismounted warfighter/ commander must perform to successfully accomplish his mission on the future digital battlefield. Innovative technology approaches are required to provide the seamless integration, synchronization and optimization of fires and effects for Non Line of sight (NLOS), Line of Sight (LOS) and Beyond Line of Sight (BLOS) assets within the FCS Unit of Action including seamless integration with mounted and dismounted platform sensors, weapons, Future Battle Command information streams and platform technical fire control. The product of this topic will be a suite of high capability cognitive decision aid components that can be easily adapted, configured and tailored to meet the full range of requirements for netted, effects based fires mandated by the Future Combat System and Objective Force Warrior including support for small unit dismounted and mounted operations. This topic will focus on the specific requirement to rapidly process distributed multi-platform targeting data, and perform optimal weapon-target pairing, scheduling and coordination of fires to maximize effects within constraints on target selection standards, commanders guidance, weapon effects, planning constraints, red and blue forces situation, resource capability/availability, terrain, mobility, communications, etc. Specific decision aiding capabilities of interest include: fire mission planning/replanning, sensor/weapon placement, sensor/information fusion and track management/deconfliction, nomination of potential targets for netted effects based on target selection standards and planning criteria, event monitoring and alerts, fire-maneuver synchronization, 4-D airspace and battlespace management and deconfliction, sensor management and battle damage assessment, sensor-shooter
link management, etc. Highly modular architectures must be developed to facilitate reuse of application software and provide a basis for component based assembly and evolutionary growth in software capability to meet evolving requirements. Implementation architectures must also address interfaces with embedded C4I, HCI, and NIMA terrain data bases and conform to emerging weapon system Technical Architecture and FCS System-of-Systems Common Operating Environment (SoSCOE) standards. Efforts should exploit emerging object oriented tools and technology, visualization technology, display technology, voice processing, artificial intelligence and information processing technologies, etc. to maximize performance and functionality, enhance MMI capability, reduce development cost and facilitate component integration and testing in a network environment. Proposals may address development of one or more reusable decision aid application components and interface modalities and must provide the domain engineering expertise required for prototype demonstration.

PHASE I: Explore advances in cognitive modeling, cognitive agent based algorithms, reasoning and planning in the presence of uncertainty and/or related technologies and formulate an efficient algorithm approach and design concept that enhances one or more capabilities to include real time situation awareness, mission critical alerting, netted effects planning, re-planning and synchronized fire-maneuver execution, coordination and de-confliction. Develop top level architecture specification and identify tools and methodology that would be applied in Phase II to support application component development.

PHASE II: Develop a detailed component design, component API specification, application scenario, software implementation, tool environment for one or more decision aid application components to demonstrate and validate component functionality and demonstrate component reuse potential. Optimize hardware/software, algorithm and interface design based on laboratory/ Battle Lab test results and provide complete documentation of hardware/software, analysis and test results.

PHASE III DUAL USE APPLICATIONS: This work has a very high probability of commercialization. The methodology, design environment, prototyping tools and component technology developed in this SBIR are applicable to a broad range of resource management and scheduling applications associated with commercial logistics, air traffic control, ground transportation and container shipping applications as well as emergency response and homeland security.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The open, component based architecture approach and automated tool development technology will significantly reduce life cycle support costs for FCS & OFW embedded software. The fires technology will permit optimal utilization and distribution of assets on the battlefield as well as reduce training and personnel requirements by enhancing automation of crew functions.

REFERENCES:

KEYWORDS: Architecture, software reuse, track management, design patterns, decision aids, data mining
A04-012  TITLE: Novel High Strength, High Precision, High Ductility Warhead Case Material

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

ACQUISITION PROGRAM: PEO Ammunition and PM Soldier Weapons

OBJECTIVE: To develop an advanced high strength Warhead metal case that can be fabricated with techniques and processes that are similar to thermoplastics. Offeror will propose and develop new materials and/or processes to fabricate precision fragmentation housings for conventional EFP Warheads that will survive high G-loads.

DESCRIPTION: The U.S. Army is developing a new family of Warheads for Future Combat Systems that will provide leap-ahead lethality, but in a reduced size and volume. The basic components of conventional Anti-Armor Warheads are the metal case, explosive billet and metal liner. The metal case serves several critical functions; it provides support to enable the Explosive Billet and Liner to survive the environments and gun launch loads and also provides mass confinement that will focus the explosive energy to the Liner for improved performance. A metal with revolutionary increase in strength (Yield Strength: > 200 ksi) would enable much thinner and lighter case designs that will still survive the high G environments, and the high strength should also provide some compensation for reduced mass confinement. There are a few materials available that possess very high yield strength, but they are very expensive and difficult to machine to the precision required.

The U.S. Army is also developing an Active Protection System (APS) with a high precision Multiple Explosively Formed Penetrator (MEFP) casing. APS is a critical component for FCS (Future Combat Systems). It will provide FCS with protection from enemy fired projectiles and missiles. The MEFP casing consists of dimples that form a focused pattern of compact penetrators that can be used to defeat incoming projectiles and missiles. The case must be produced to high tolerance and be produced with a high strength to survive the APS launch environments. An added requirement for good ductility is needed for this application.

Phase I: Using an advanced material, design and demonstrate (in subscale warhead tests) a high strength, high precision case for conventional EFP Warheads. Such a material should be characterized sufficiently to enable preliminary hydrocode modeling (feasibility analysis).

Phase II: Develop, fabricate and demonstrate prototype cases for both conventional EFP Warheads as well as MEFP APS applications in accordance with specific characterizations outlined in Phase I. Refine hydrocode modeling with results from Phase I.

PHASE III DUAL USE APPLICATIONS: There is very large range of commercial applications for a high strength metal that is easier to machine and process. They include structural components, aerospace components, automobile parts, and bone part replacements.

REFERENCES:
1) “Multiple Explosively Formed Penetrator Warhead Technology” 2001 International Ballistics Symposium
2) "Common Smart Submunition STO"

KEYWORDS: Warhead, Gun Launched, High Strength Material, Manufacturing Technologies

A04-013  TITLE: Novel Use of Magnesium Composites to Reduce Weight of Mortar Systems

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Use Magnesium Composites to Reduce the Weight of the Lightweight Mortar.
DESCRIPTION: The Army is in the process of reducing the weight of existing systems and creating new lightweight systems. In order to accomplish this goal it is necessary to explore the use of innovative materials and application processes. This SBIR looks at the constant problem of system weight reduction. Magnesium Composites have been proven to have desired density characteristics for numerous military applications. Magnesium has been overlooked in the past partly because of problems with corrosion. New technology has made it possible to prevent or greatly reduce the corrosion of Magnesium. Magnesium has the lowest density of engineering metals. This SBIR will explore the use of Magnesium Composites in the development of bi-pod legs for the Lightweight Mortar. Bi-pod legs made of Magnesium Composites will assist in achieving the overall all weight reduction goals for FCS.

PHASE I: Demonstrate the feasibility of a process using Magnesium Composites to form bi-pod legs for the Lightweight Mortar. Investigate existing processing techniques used for Magnesium Composites. Study existing methods to reduce/eliminate corrosion problems associated with Magnesium. A trade off analysis will be conducted to compare the potential Magnesium Composite bi-pod legs to existing bi-pod legs.

PHASE II: Determine the hardware requirements specific to the selected fabrication process for the Magnesium Composite bi-pod legs. Establish evaluation criteria for the bi-pod legs. Manufacture prototype bi-pod legs for the Lightweight Mortar. Subject the bi-pod legs to appropriate metallurgical evaluation. Evaluate the bi-pod legs based on the selected evaluation criteria. Explore other systems that the Magnesium Composite bi-pod legs may be applied to. Explore other items that may be fabricated using Magnesium Composites. Recommendations and conclusions will be included in the final report.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications include the production of bi-pod legs for numerous military systems. It will be possible to expand the fabrication process to develop Magnesium Composite parts that can be used by private defense contractors, aerospace industries and automotive industries.

REFERENCES:
1) Magnesium Corrosion http://www.corrosion-doctors.org/MatSelect/corrmagnesium.htm
2) Manufacturing of Magnesium Structures Selectively Reinforced by MMC Inserts Dr. C. Hausmann http://www.empa.ch/plugin/template/empa/*/22779/---/l=1
3) Magnesium joining - new developments aid industrial fabrication TWI WORLD CENTRE FOR MATERIALS JOINING TECHNOLOGY http://www.twi.co.uk/j32k/unprotected/band_1/c1093.html

KEYWORDS: Magnesium, Lightweight, Corrosion, Metal Matrix Composites

A04-014 TITLE: Innovative Modular Interlocking Pallet Containers

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To develop a modular design that when 16 of these containers/pallets are joined together they form a 20' ISO equivalent unit. The matrix should be a 2 x 2 x 4. If successful, this design would greatly support DoD logistics by eliminating banding, blocking and bracing, and a myriad of platforms. Retrograde operations would be significantly enhanced; would work extremely well in both the DoD and commercial logistics world; mate with existing handling equipment; and support FCS delivery and be a significant enabler for sea-basing operations.

DESCRIPTION: The individual modules will be required to behave as individual pallets as well as TEUs depending on configuration. Flexibility of design and managing tare weight will be key enablers of this effort. The following design performance metrics will be closely evaluated and monitored to ensure the attributes of the approach are consistent with clear goals.
Each module should have a tare weight not to exceed 450 lbs. Top to bottom interlocking should be automatic when assembled with the use of a fork lift. Each module should have 4-way fork lift capability. Max payload for each module should be up to 3,000 lbs. All other interlocking (excluding top to bottom) if manual should take no more than 5 seconds per connection. Build order should be avoided. Desired that each module be capable of being "knocked down" when empty. When assembled in a 16 pack, should be compliant with ISO 1496-1. Each individual module should survive rough handling testing IAW Mil-Std-1660. Either separately or together the pallet module should be airtransportable on C130, C17 and C5 aircraft without any additional platforms. Each module should have it's own means of physical security. Module should be airdroppable.

PHASE I: At the conclusion of Phase I at least 2 mature design concepts to include FEA analysis should be provided to determine concept feasibility - possibly prototype locking mechanism.

PHASE II: At the conclusion of Phase II a prototype shall be developed and demonstrated to the government. Testing shall be conducted IAW Mil-Std-1660 and ISO 1496-1.

PHASE III DUAL USE: If successful, this type of system could rapidly transition to the commercial world. Benefits could facilitate drop shipments of overseas products to retail outlets greatly reducing the need for distribution centers. Moreover, would facilitate the shipment of relatively small orders. In the end, commercialization would greatly reduce the per unit cost of this item.

REFERENCES:
1) http://www.seabox.com/index.cfm?cat=MC&subcat=1&page=2

KEYWORDS: modular design, pallets, retrograde operations, sea-basing

A04-015 TITLE: Explosive Detection Device

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and build an inexpensive portable explosive detection device capable of determining the presence of munitions and significant explosive residue within munition containers. The device must be able to operate in remote outside environments and quickly determine whether munitions or explosive residue are present in large stacks of presumably empty containers.

DESCRIPTION: Munition deployments & operations generate enormous quantities of packaging which must be certified as “explosive free” prior to re-use or turn over to recycling centers. Current techniques require tedious manual screening which is fraught with errors. This results in serious and sometimes catastrophic explosive accidents as commercial recycling companies process supposedly empty packaging which actually still contains a munition item or significant amount of explosive residue. Detection device must be portable to facilitate operation in deployed, remote outdoor areas without electric service. Device must also be able to operate within a broad range of temperatures from approximately 0 F to + 140 F and function properly in adverse weather conditions such as rain, snow, etc. Success will be measured by the speed and ease with which a randomly piled stack of munition packages measuring approximately 4000 cubic ft may be verified “explosive free” with 100% accuracy. Device must comply with all requirements for safe operation in explosive environments. (Hazards of Electromagnetic Radiation to Ordnance - HERO Safe)

PHASE I: Develop basic technology concept for remotely detecting munitions and explosive residue in munitions containers. Provide specifications for device, outline operational protocol and assure compliance with HERO requirements. Demonstrate design proof-of-principle by detecting a single, Army-supplied small munition packaged in its standard munition container using initial bread-board components.
PHASE II: Develop and demonstrate a prototype system in a realistic field environment with Army-supplied munition and packaging samples. Conduct testing to prove feasibility over extended operating conditions and expand detection capability to a single small munition located within a large stack of containers. For example, detecting a single 5.56mm round loose in a 105mm wooden box=GOOD, detecting a single 5.56mm round loose in a 4000 cubic foot stack of 105mm wooden boxes=GREAT.

PHASE III DUAL USE APPLICATIONS: This device would have broad application in the military, commercial security and anti-terrorist markets in the remote detection of explosives. Examples include minefield & Military Operations on Urbanized Terrain (MOUT) screening, port operation ISO container screening, airline baggage checks as well as personnel screening at Government facilities and large public sporting and entertainment events. Potential system operators include military & industrial security personnel, airport security teams, state police, Sheriffs' organizations and border patrol personnel.

REFERENCES:
1) SB 742-1, Chapter 2-4b(4)
2) NAVSEA OP 3565/NAVAIR 16-1-529
3) NAVSEA Ord 30393 - Design Principles and Practices for Controlling the Hazards of Electromagnetic Radiation to Ordnance (HERO Design Guide)

KEYWORDS: Sensors, Detection, Explosives, Residue, HERO


TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop and demonstrate state-of-the-art small form factor, minimal loss, antenna designs for optimal omni-directional transceiving of low power signals in wireless “health” monitoring systems

DESCRIPTION: The Army has developed sophisticated electronic devices for lifecycle environmental monitoring of munitions and other commodities. These devices have been developed as part of the Army’s Remote Readiness Asset Prognostic/Diagnostic System (RRAPDS), which will continually monitor high value munition “health” status for 10-15 years with their original power supply. Integral to these devices, is a short range wireless communication capability for data retrieval.

There is a significant need for a small (low volume) antenna that can fit inside the case of the sensor device and provide to the greatest extent possible – a nearly omni-directional capability for signal reception and transmission. Additionally, the antenna design needs to be optimally power efficient – that is, ideally it would provide a degree of gain, and at least, minimize losses, since power conservation is critical to long operating life of the system. Various commercially available planar antennas have been tried, and all have been found to be insufficiently omni-directional to ensure reliable communications. Additionally, they are not very power efficient. Monopole antennas have been tried that work reasonably well, however, they have been external to the case. An external location is deemed to be too vulnerable to deliberate or accidental damage/Removal. Placing the monopole internal to the case and electronics has radically degraded performance.

The following further delineates requirements for the antenna design:

1. The antenna system shall fit within a box that is approx. 2.5” wide and 5” long and its thickness should be roughly 1/16th inch or less.
2. Operating frequency in the range of 425 – 435 MHZ.
3. Input power level approximately 5-10 milli-watts and 50 ohms.
4. Ideally the antenna will be easily produced at low cost and tolerant of a wide range of environmental conditions.
PHASE I: Develop and demonstrate initial candidate designs.

PHASE II: Further refine designs generated in Phase I. Demonstrate performance and provide field measurements that show the degree of omni-directionality and power gain/loss. Design antenna for low cost producibility. Incorporate into the RRAPDS sensor device package and demonstrate performance capabilities.

PHASE III Dual Use Applications: Low power, unlicensed wireless devices are becoming increasingly popular for a wide number of uses as their costs have come down. A novel, low cost, highly efficient, small, omni-directional antenna would no doubt be of utility for many of these systems since it would enable performance improvements, and packaging improvements, and power efficiency – resulting in greater life.

REFERENCES:
2) http://ncn.purdue.edu/inac/suri2003/Hong_slides.pdf
3) http://www.iee.org/OnComms/pn/antennas/bookreviews.cfm

KEYWORDS: wireless communications, antenna, planar antenna

A04-017 TITLE: No-Preset Autonomous Proximity (NPAP) Fuzing-Med Cal Munitions

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: PEO Ammunition and PM Soldier Weapons

OBJECTIVE: Development of the fuzing technology necessary to fire a 40mm round from existing unmodified assets (e.g., Mk19 Grenade Machine Gun) which will airburst before target impact via proximity fuzing. The "unmodified weapon" is the key distinction: the need exists for a system that does not require any preset ("No-Preset") and without the logistical complexity or cost of refitting fielded systems with expensive fire control systems.

DESCRIPTION: The JNLWP-funded Crowd Control Concept Evaluation Program identified the need for increased range and stand-off for Non-Lethal (NL) capabilities, as a significant capability gap existing in the 50m-1000m direct fire engagement range, which also has Force Protection, Maritime, and (Military Operations on Urbanized Terrain) MOUT scalable effect and Lethal applications. The identified technical solution of delivering the desired effect includes a requirement for a before-the-target proximity airburst actuation. One technology that delivers this capability exists in the form of a fuzed munition combined with a sophisticated fire control refit kit for the candidate weapon, but this solution has high adoption costs, as it requires both new ammunition as well as fleet weapon refits. The need is to develop the same proximity airburst capability that is entirely contained within the munition, which obviates the need/expense/logistics of weapon refits, which should be achievable through advanced sensor technology.

PHASE I: Design a proximity fuze capable of the above described operation. Perform trade-offs of fuze size, cost and sensitivity with respect to the accuracy and reliability of operation. Identify the enabling technology and its innovation. Finalize candidate design for transition to Phase II.

PHASE II: Continue enabling technology development. Construct prototype device(s) for evaluation.

PHASE III, DUAL-USE APPLICATIONS: Small and affordable proximity fuze technology is incredibly valuable to the military community because it opens up the opportunity for smaller systems to benefit from the additional capability afforded. It is also suited for technology transfer for dual-use because the technology development’s focus on affordability means that a small remote sensing capability can be broadly proliferated into commercial applications which are currently cost and/or power budget limited. Potential applications include security systems
(homeland, commercial, domestic) where the benefit is a lower cost for capability, or improved capability/coverage/performance at constant cost. It similarly enables semi- and fully autonomous automated (robotic) systems for inclusion of sensors to provide obstacle avoidance for self-guided route-finding and self-protection at very low size/cost/power budgets. It similarly can be applied as an affordable, small and low power sensor in industry and transportation from forklifts and automobiles to heavy trucks (matrices providing 3D proximity sensing for accident avoidance from the warehouse to the highway).

REFERENCES:
1) http://www.ggw.org/~cac/Proximity_Fuze.html
2) http://www.smecc.org/radio_proximity_fuzes.htm

KEYWORDS: Proximity, fuze, air-burst, sensors

A04-018 TITLE: Near-Vehicle Situational Awareness and Omnidirectional Weapons Detection System

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PM Tanks, USMC and PEO Soldier

OBJECTIVE: Design and build an innovative, near-vehicle, situational awareness device with automated capabilities to detect and locate random attacks.

DESCRIPTION: Opportunistic hostile attacks present a constant threat to the life of US troops while on surveillance in ground-combat vehicles. With over 15,000 military vehicles in operation in IRAQ alone, effective force protection to war fighters in these vehicles becomes a significant challenge. Technology development leading to an inexpensive, but effective omnidirectional, simultaneous, near-vehicle situation awareness system would have an immediate benefit to US forces. Existing ground weapons detection and near-vehicle situational awareness technologies are limited in terms of sensor field of view, range, size, and reliable target detection and location. Reliable detection and situation awareness are particularly difficult while the vehicles are in motion. This SBIR effort will focus on innovative technologies for vehicle force protection and for breakthrough surveillance technologies that would provide reliable detection on a moving vehicle. The following capabilities are solicited: 1) 360-degree sensor with multiple sensing modalities, such as LWIR, acoustics, video, and any other effective sensor modalities (we encourage at least two sensor modalities); 2) Real-time (~ 1 second) on-board multi-modal signal/image processing capability with compact size and low-power consumption; 3) Reliable target detection and location algorithms with quantifiable performance; 4) Highly efficient electronics stabilization and super resolution algorithms that can be processed in small electronics (less than 40 cubic inches); and 5) Simple and quick method to alert the 1st responder as the man-in-the-loop. The operation threshold for situation awareness is at a range of 30-300 meters depending on the selection of sensor modalities, and 30-800 meters detection range of random lethal attacks.

PHASE I: Design a preliminary sensor modalities device and demonstrate the effectiveness of proposed approach in real-time; evaluate the form factor that can be achieved and reliability during all typical environmental conditions for security and monitoring forces.

PHASE II: Develop a prototype real-time capability and perform preliminary field tests using moving vehicles in urban areas.

PHASE III DUAL USE APPLICATIONS: With over 15,000 armed vehicles in operation at IRAQ, the system developed can be used immediately to save the lives of war fighters. The sensor technology to be developed under this program can also be used in UAV and UGV programs. For civilian uses, this 360° situation awareness technology can be used for a variety of homeland security applications such as border monitoring, airport security, high value (power plants, chemical plants, water plants, etc.) facility protection, and transportation security (subways, trains, highways, bridges, tunnels, etc.). Commercially, it can be used for detecting animals on highways, avalanches, protecting railroad crossings, and for ground control applications.
A04-019  TITLE: Innovative Wireless, Self-Mapping Small Baseline Acoustic Array

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and build a ruggedized, weapon deployable, wireless, and self-mapping miniature microphone device with a low-cost onboard digital signal processing system. The shape of the miniature microphone device and aperture array should dictate the development of the detection and classification algorithms’ performance. The design must have the ability to send the processed data either to the central processing node as one of the networked sensors or perform as an independent sensor system. The design should incorporate signal processing algorithms for bearing estimation and classification, whether it is a directional or omnidirectional acoustic sensor system.

DESCRIPTION: Remotely deployed, lightweight, and miniature unattended ground sensor devices are needed for the future Objective Force to extend the reach into tactical areas and provide early warning and assessment of enemy threats so as to increase situational awareness to commanders. Field test results from recent demonstrations of target detection systems show that significant improvements have been realized in predicting the direction of incoming threat vehicles, however, the physical dimensions of currently fielded sensors do not lend themselves to remote deployment. Systems incorporating small microphone devices with low-cost onboard DSP and wireless communication are becoming available as of late, but tend to perform poorly with limited long-range target detection capabilities. This program will leverage existing sensor technology with state-of-the-art acoustic sensor algorithms. An emphasis will be placed on conserving battery power using sensor platforms that incorporate low-power electronics and can be integrated with Unmanned Ground Sensor (UGS) systems, in order to provide extended situation awareness for maximizing Force protection.

PHASE I: Design innovative acoustic long-range target detection, and classification algorithms with state-of-the-art wireless technology on miniaturized platform. The detection algorithms should demonstrate the ability to resolve ground vehicles at minimum distances of 500 meters from the array and a bearing estimation accuracy of at least 3°. Development of a wireless real-time operational display indicating device location, line-of-bearing to target, coupled with a database acquisition capability is desired. Geometry of the wireless, self-mapping acoustic array box should be able to be resolved from linear, circular and elliptical shapes.

PHASE II: Develop a prototype system and perform preliminary field testing.

PHASE III DUAL USE APPLICATIONS: This system would have wide utility in border patrol, airport ground traffic tracking, to cue passive sensor system (IR, magnetic, etc.).

REFERENCES:
Keywords: Sensors, wireless, self-mapping, detection, classification, tracking

KEYWORDS: Sensors, wireless, self-mapping, detection, classification, tracking

A04-020 TITLE: Rapidly Emplaced Devices to Attach Sensors/Demolitions to Structures

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PM Close Clombat Systems and PEO Ammunition

OBJECTIVE: Design, build and experiment with a low power, non-invasive, portable device that can be rapidly adhered to various structures, to include: buildings, bridge abutments on corners, vertical surfaces and inverted surfaces. The device should have the capability to be used while submerged in a fluid. The device is required to have the capability to support a payload, i.e., sensors, demolition charges, static charges, while remaining connected to the surfaces as described above for several minutes.

DESCRIPTION: Currently a variety of items; magnets, anchors, shelves, tape and adhesives are used in surveillance and demolition operations. Most of these approaches are time consuming, putting the User at risk in hostile environments. All of these approaches are surface and environment dependent, requiring the User to design and build support fixtures, as well as carry into the field a broad array of materials to build these support fixtures. A single device that can adhere to a variety of surfaces (regardless if the surfaces are smooth, textured, porous, submerged in fluid or coated with moderate dirt) and will allow the rapid emplacement of sensors or demolition charges, particularly in urban and built up areas. The User will be able to turn the device on and place it on a surface without any fixtures or support devices. The device will be hand emplaced. The devices can be used by Engineers to emplace sensors that can evaluate bridges and/or emplace demolition charges on obstacles. The current technology shows promise in the area of adherence to walls, ceilings, etc. The device must be lightweight to be carried by the User, rapidly emplaced (within 1-2 seconds of being placed on the surface), adhere to a surface for 30 minutes up to 3 hours. In addition the payload capacity should be able to hold up to 5 lbs. Systems of longer duration are also of interest as well as systems capable of other than static use. The system should be a modular building block to allow for further technology insertion.

PHASE I: Research the feasibility of such an item. Demonstrate proof of principle and develop a prototype device that is capable of adhering to walls, with a payload capacity of 3 lbs, and able to sustain 30 minutes on the surface.

PHASE II: Develop and demonstrate a prototype device in a realistic environment suitable for experimentation by Users. Upon completion of experiments, develop sample prototypes based on User inputs, i.e., robustness, ease of use, performance, etc.

PHASE III DUAL USE APPLICATIONS: This device will have wide utility in the civil engineering and construction areas, particularly in remote areas. The device will also have application in the area of domestic security operations, where surveillance is required.

REFERENCES:

KEYWORDS: sensors, demolitions charges, adherence, surveillance, rapid emplacement

A04-021 TITLE: On-Board Recorder for Data Acquisition During Firing and Flight of Projectiles

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

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and build a reusable On-Board Recorder (OBR) which is to be integrated into inert 155mm, 120mm and 105mm projectiles for the purpose of obtaining essential projectile performance data. The OBR is to begin recording data at the instant the weapon is fired. Data recorded will include information about the conditions inside the cannon barrel as well as in-flight data. A minimum of eight channels capable of recording data from accelerometers, pressure gauges, and other transducers at a sampling rate of one megahertz as well as collecting data from the GNC (guidance & navigation computer) are to be provided. Upon recovery of the projectile the recorded data is to be downloadable into a PC (personal computer).

DESCRIPTION: In the continuing development of precision guided munitions, also referred to as fire-and-forget smart munitions, the harsh environment inside the gun barrel to which munitions are subjected during firing is of critical importance. The collection of accurate acceleration and pressure data, as well as other performance parameters (stress, temperature, etc.) is quintessential to ensuring the survivability of these munitions when fielded. Continued in-flight recording of data such as set-back and set-forward acceleration, spin rate, and GNC data is also paramount to the development of an effective weapon. At present, an OBR is in use providing data in support of the XM982 Excalibur program, the MRM (Medium Range Munitions) program, IMU (Inertial Measurement Unit) Development and other ARDEC programs as well as outside customers. However, significant shortcomings in the existing OBR’s capabilities as well as its physical size, which prohibits its use in 120mm and 105mm projectiles, mandate a completely renovated design. Although the objective of this SBIR may appear to be merely an upgrade, the research effort and innovative designs required to integrate the desired specifications into a canister of this small size is formidable. Furthermore it is more than probable that new technology will arise from this process. The specifications to be incorporated in the new OBR are as follows:

· Built-in self-test capability
· Programmable offsets and gains
· Delay timer adjustable from 0-60 minutes
· Pre-trigger adjustable 10% of high-speed sample time (about 2.5 millisecond)
· Programmable/variable data rate throughout flight duration
· Expandability from basic 8-channel up to 18-channel
· 32-Megabyte memory capacity (possibly non-volatile)
· Analog/Digital accuracy: 8-bit minimum (10-bit preferred)
· USB1.1 interface to PC
· Programmable anti-aliasing filter coupled to variable data rate
· Data sampling rates of 1 Megahertz (2 Megahertz desirable)
· Crystal controlled stabilized clock (possibly programmable)
· Operational on 5V supply power (3.3V desirable)
· G-switch trigger on 400G’s
· Flex-board/flex-cable/micro-connector design (desirable)
· Physical size not to exceed 3.00 inches long by 2.50 inches diameter.
The OBR is to withstand a set-back acceleration of 20 KG’s for 4-12 milliseconds, a set-forward acceleration of 15 KG’s for a minimum of 300 microseconds, balloting to ±6 KG’s and a spin rate of 340 RPS (revolutions per second). It is to be operational in a temperature range of -45° to +145° Fahrenheit.

PHASE I: Develop all block diagrams and flow charts necessary to describe the system’s operation. Provide preliminary electronic schematics. Select all key components and provide preliminary drawings of the physical layout showing the location of PCB’s, connectors, cabling and all major components. Incorporate as many of the above specifications into the design as possible consulting with the PMIG (Precision Munitions Instrumentation Group) Telemetry Group where compromises are to be suggested. Demonstrate feasibility through the use of computer simulations and/or prototyping of specific circuits.

Note: The contractor in not responsible for the OBR’s power supply as the PMIG will develop and provide the OBR’s battery module.

PHASE II: Construct a complete operational prototypes (battery modules supplied). PMIG will subject the prototype to rigorous electronic testing as well as to environmental tests in a temperature chamber and in the air and rail guns. Final qualification is to take place in the field through firings from 155mm, 120mm and 105mm artillery. The OBR’s must demonstrate the ability to effectively collect and download quality data.

PHASE III DUAL USE APPLICATIONS: The maturation of this OBR technology will have immediate utility for manufacturers of guidance and navigation systems, projectiles, fuzes, and other munitions related products. Moreover, the technology developed will be suitable to any commercial application where data collection at high sampling rates is required, particularly where a rugged self-powered data recording module is desirable. Force, pressure, torque, strain, motion, temperature and flow measurements as well as the detection of micro-cracks and flaws by the utilization of appropriate transducers are typical examples.

REFERENCES:
1) XM982 http://www.globalsecurity.org/military/systems/munitions/m982-155.htm
2) 155mm projectiles http://www.fas.org/man/dod-101/sys/land/155.htm
3) 120mm projectiles http://www.fas.org/man/dod-101/sys/land/120.htm

KEYWORDS: harsh environment, transducers, GNC, high-speed sampling, data recording, signal conditioning, digitization, logic & control, memory, high-G survivability

A04-022 TITLE: Mega-Volt X-Ray Digital Imaging Inspection System

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: PM, Combat Ammunition Systems

OBJECTIVE: Develop a mega-volt x-ray digital imaging system and specimen handler that will function at or above 3 MeV without excessive noise or susceptibility to scattered radiation. The system should support advanced digital x-ray image processing techniques, i.e., CT-scanning, limited data reconstruction applications, laminography, and time-delay integration (TDI) in a production environments.

DESCRIPTION: Acquisition of high spatial resolution digital x-ray images of large munitions (having cross-sections of five or more inches of steel) needed for automated and semi-automated non-destructive inspection is very difficult. X-ray energy of three MeV or greater is generally required. X-rays at such high energy either do not interact with (and so can not form x-ray images) or harm current digital x-ray imaging systems. Although significant recent progress has occurred in replacing standard x-ray film with electronic image formation systems for low voltage systems, the technology can not be implement on high energy systems. Techniques such as cone-beam computed tomography (CT), digital laminography, TDI, and 3D reconstructive imaging with imperfect or incomplete data are implemented in such low voltage systems. Existing X-ray imaging systems operating at 3 MeV...
have not provided the spatial resolution and deep dynamic range [12-16 bit digitization/true dynamic range 11-14/15 bits] required for industrial CT, laminography, TDI, etc.. A particularly insidious problem for electronic systems is very large values of shot noise in individual pixels or groups of pixels that result from direct interactions of scattered x-rays in the electronics' storage registers; such interactions make reconstructive imagery very difficult if not impossible.

This solicitation is for development of an digital x-ray imaging system that resolves these issues, as well as for the motion/motion control system that can provide an acquisition system for accomplishing cone-beam CT, TDI, limited data CT, laminography, and other associated digital x-ray imaging techniques on rounds exceeding 100 millimeter in diameter. The system design should be such that it can be used at army production facilities to verify product development techniques and spot product inspection or even full production rate inspection if necessary.

PHASE I: Experimentally confirm the critical concepts will function properly at the high energies. Complete the system design for an x-ray camera that addresses the critical issues described above, as well as a motion/motion control system that can provide a complete acquisition system for accomplishing cone-beam CT, TDI, limited data CT, laminography, and other associated digital x-ray imaging techniques for 155 mm rounds.

PHASE II: Develop and fabricate a system. Develop, test and demonstrate software that operates and controls all components and performs advanced digital reconstruction techniques including cone-beam CT, TDI, limited data CT, laminography, and other associated digital x-ray imaging techniques. Test its durability and functionality using ARDEC’s two MeV Linatron, 450 KeV X-ray source, and 25 MeV Betatron.

PHASE III DUAL USE APPLICATIONS: Military applications include inspection of all rounds larger than 100 mm in diameter, such as the 120 mm and the 155 mm rounds. Commercial applications include inspection of thick metal components, and inspection of cargo carriers, trucks, etc. required for detecting illicit material transportation.

REFERENCES:
2. High Resolution Digital Flat-Panel X-Ray Detector- Performance and NDT Applications J.M. CASAGRANDE, A. KOCH, B. MUNIER, P. DE GROOT THOMSON TUBES ELECTRONIQUES 38430 MOIRANS FRANCE Contact 1. INTRODUCTION Film screen radiography has been used for ...
http://www.ndt.net/article/wcndt00/papers/idn615/idn615.htm
3. Image Quality comparison of Digital Radiographic Systems for NDT P. Willems, P. Soltani, B. Vaessen Agfa NDT, Septestraat 27, B-2640 Mortsel, Belgium Phone: 32-3-4442881, Fax: 32-3-4447655 Contact 1. Introduction Various digital X-ray detectors ...
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5. Design of a Novel detector for Industrial X-Ray Computed Tomography (XCT) B. Wei W. Xian Y. S. Pan Department of Optoelectronic Engineering, University of Chongqing, Chongqing 400044, P.R.China Contact Abstract Industrial X-ray Computed Tomography ...
http://www.ndt.net/article/wcndt00/papers/idn754/idn754.htm
6. Radiographic Testing - A comparison of Standards for Classical and Digital Industrial Radiology Uwe Ewert, Uwe Zscherpel, BAM-Berlin, Germany Contact Introduction New digital radiological techniques have been developed which may replace classical techniques ...
http://www.ndt.net/article/wcndt00/papers/idn324/idn324.htm

KEYWORDS: Non-destructive inspection, radiography, laminography, tomography, homeland security, cargo inspection
TITLE: Microsystems Technology (MST) for Fuzing in Low-Spin/Low-G Launch Environment

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Weapons

ACQUISITION PROGRAM: PEO Tactical Missiles, PM ARM

OBJECTIVE: Design and build novel prototype MEMS (Micro-Electro Mechanical Systems)-based S&A (Safe and Arm) devices that can be utilized in a low-spin/low-G launch environment such as the 2.75 inch rocket or hellfire missile system.

DESCRIPTION: Microsystems Technologies (MST) or MEMS technologies have been successfully applied to the fabrication of micro scale fuze components. A metal MEMS Safe & Arm (S&A) device has been designed, manufactured, integrated with energetics and fuze electronics, and tested for high-spin/high-G 20 mm airbursting munitions. Assemblies built from these components have been demonstrated to survive the severe launch environments specified for the MEMS S&A Development Project sponsored by the Joint Services Small Arms Program. Produtibility problems that were encountered in the earliest stages of MEMS S&A development efforts included stiction, poor adhesion, over-etching, undercutting, and breakage. The Government is pursuing, micro machining processes that have a high probability of avoiding these problems.

An ultra-miniature (less than 2 cm cubed in volume) S&A device is needed to meet the low-G/low-spin fuzing requirements for advanced 70 mm rocket applications. The tasks described herein are intended to cover design and fabrication of innovative initial prototype components for the S&A device. The primary purpose of this SBIR effort is to develop and demonstrate innovative improvements in manufacturing technologies that hold promise for eventual low cost, large quantity production of micro-scale S&A components.

PHASE I: Research and design an innovative S&A device that will be capable of improved functionality, size reduction, improved manufacturability and potential for automated assembly. To operate effectively under all specified conditions, and to accommodate a micro-scale firetrain, the components will have aspect ratios that are typically greater than 15 to 1, very precise (micron-scale) feature geometries, functionally smooth, straight sidewalls, and must be fabricated of materials that will be low in cost and which will produce rugged parts that can be readily assembled to create a smoothly operating mechanism that will operate reliably without lubricants and that is free of the risk of stiction, delamination, etc.

PHASE II: Produce rugged and functional sample prototype components using appropriate MST processes for use in assembling S&A devices. The contractor will perform appropriate inspection procedures and metrology on the parts.

PHASE III DUAL-USE APPLICATIONS:
Military:
· US Navy Guided Interface Fuze (GIF) Program Block II (aka US Army Course Correction Fuze (CCF)), hardened fuzing. These programs require fuzing or guidance systems that have increased features (i.e. GPS, anti-jamming, self-destruct, etc). MEMS emerging technology will realize volume reductions thereby enabling increased functionality.
· Polymer Injection molding platforms, when utilized, will provide low-cost continuous parts production as an alternative to dwindling “watchworks” fuze suppliers.
Commercial:
· Disk drives for personal computers and other portable applications are already approaching the size of a quarter and will be getting smaller. Micro parts made with conventional technologies such as stamping and EDM are insufficiently precise to use in robust mechanisms that are required to withstand rough handling, including shipping. Silicon devices suffer from chipping and stiction. Hence, only high aspect ratio, high precision metal or plastic parts can meet system requirements.
· Generation-after-next microprocessors will run so hot that conventional fans and heat sinks will be insufficient to cool them. LIGA-based processes developed under the SBIR may be needed to fabricate these precise metal micro-fluidic cooling devices.
· Current mammography equipment has insufficient resolution to readily identify tumors in their early stages. It has been shown that extremely fine, precise metal gratings can be made to focus x-ray beams such that the resolution can be substantially improved at relatively low cost. Technologies developed under the SBIR would facilitate fabrication of such gratings having sufficiently fine pitch.

REFERENCES:

KEYWORDS: LIGA, Microsystems Technology (MST), High Aspect Ration (HAR), Micro Electro Mechanical Systems (MEMS), Safe & Arm (S&A), fuzing

A04-024 TITLE: Self-Aiming Laser Acoustic Target Designator/Classifier

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Weapons

ACQUISITION PROGRAM: PM Close Combat Systems

OBJECTIVE: A novel functional combination of scanning laser and acoustics sensor information is desired to facilitate development of a small-sized, low-cost automatic target recognition/tracking subsystem suitable for wide scale application in remote deployed systems for highly reliable warhead/effects aiming and/or automated laser designation. The objective is to develop a prototype subsystem which can track, classify and then achieve a highly reliable “crosshairs lock” on ground targets through the functional synergy of passive acoustics (strengths in tracking/classification), active laser (ranging/tracking potential), and “acoustic classification” of the laser return (advances in laser vibrometry which facilitate classification as well as target aimpoint).

DESCRIPTION: No practical, low cost sensor subsystem suitable for remote deployment as part of networked sensors/munitions has been developed to date which is capable of automatically tracking and classifying threat vehicles and holding a reliable “crosshairs lock” on target. The use of high resolution cameras or other active imaging systems in automated target tracking systems have made certain strides, but their large size, high cost, and inability to demonstrate reliable and accurate target aim-point make them unsuitable for remote deployment or wide scale use as sensor systems which can effectively direct effects to target with high precision. A small sized laser scanning subsystem has the potential to efficiently scan a target area with scanning area and scanning passes minimized through innovative synergy with the acoustics solution. The potential also exists to exploit new “laser-acoustic” classification technologies which shows promise to very quickly classify and locate vehicles at long range with high precision.

Considerable design freedom exists in optimizing methodologies and algorithm solutions for laser scanning, tracking, and classification while considering potential synergy with the acoustics solution. The following describes a potential concept. An acoustic ground platform is capable of pointing the scanning laser subsystem in the general bearing direction of the target within sufficient accuracy to put the laser scanning subsystem in the target basket. The proposed scanning laser system, employing innovative scanning and classification methodologies, has the potential to quickly determine vehicle presence, range, heading and type. Laser vibrometry (or interferometry) analysis of the laser return signal can be used to accurately classify the vehicle in much the same way that current land acoustics systems classify targets. The accurate determination of exact vehicle heading, range to target, and confirmation of target type by the scanning laser has the potential to greatly assist the acoustic solution, so that tracking accuracy can be significantly improved. The synergy between laser and acoustics thus has the potential to provide highly accurate tracking, and the use of acoustics has the potential to significantly reduce overall laser on time during the tracking/classification process. Now the system is poised to provide a “crosshairs lock on target” to cover a wide range of possible targeting or laser designation solutions.

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The advantage of this unique point, classify, and lock on target capability can be exploited in many applications. Ground based munitions systems can achieve huge gains in their ability to functionally link sensors with shooters and to more effectively bring effects on targets. The potential also exists to develop a family of improved automated ground based target trackers and laser designators so that a variety of laser guided weapon solutions can be leveraged. The potential exists to efficiently deploy such devices over relatively large surveillance areas, linking them together in cooperative networks so as to benefit from smart system level tracking and laser designation algorithms. (Note: at this point in the development cycle system level network solutions will not be developed, however their potential shall be considered in the overall design).

The key technology challenge is to develop innovative, synergistic laser/acoustic scanning methodologies/algorithms which can efficiently feedback sufficient information in the target scanning area to effectively classify, track, and then ultimately provide reliable target aimpoint. Minimizing laser power, area of target illumination, and overall laser time on target are critical risk areas which must be addressed so that the overall solution can be optimized for automated laser designation systems or stealthy operation in target location/classification applications.

PHASE I: Develop objective requirements and preliminary design of the scanning laser subsystem. Conduct tradeoffs of scanning laser and aiming approaches. Develop preliminary scanning laser classification/tracking solution which can benefit from and support the acoustics classification/tracking solution. Develop preliminary target classification database using laser vibrometry analysis so that initial algorithms can be conceptualized to scan the target area and provide reliable target aimpoint. Provide a detailed functional description of the automated target location scanning, aiming, and classification algorithm.

PHASE II: Complete database of laser vibrometry data for approximately 7 ground vehicles. Mature the laser scanning, classification, and target tracking algorithm. Develop and fabricate a prototype laser/aiming mechanism and electronics classification and aiming control subsystem. Test the ability to determine laser classification/tracking and overall aiming potential using stationary vehicles. Functionally integrate the prototype subassembly with the Acoustics Center laptop based acoustic array classification/tracking system. Conduct prototype demonstration of subsystem classification/tracking and aiming capability against various stationary and moving threat vehicles.

PHASE III DUAL-USE APPLICATIONS: Efforts continue to optimize the functional combination of sensors and effects on the battlefield. A wide range of effective low cost weapons systems will be possible which take advantage of the improved target tracking/designation and aiming potential of the acoustics-laser subsystem. This effort also supports the future development of a family of remote deployable networked laser-acoustic designator systems which can effectively replace current soldier operated systems. Such systems have the capability to be linked together in cooperative networks to improve overall system performance, reduce laser detectability, and to efficiently cover large battlefield surveillance areas.

The development of innovative scanning laser target identification/tracking methodologies holds the potential to identify and track almost any object of interest and thus may suit many commercial applications. Such systems may benefit from the synergy of acoustics and laser scanning or simply from the improved scanning/targeting solutions. The technologies could be exploited as part of security systems, surveillance systems, or traffic monitoring systems which feedback exact location of acoustical disturbances. Lasers are also seeing new exciting applications in the wide area monitoring of ground disturbances through laser analysis of atmospheric effects. The development of smart low-cost automated laser aiming platforms will improve and expand such applications.

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4. L. Sundkvist, Laser radar for non-contact vibration measurements and as part of a system for automatic target identification, Linkoping University at Department of Physics and Measurements Technology (IFM) Report, 1996.

KEYWORDS: laser, vibrometry, acoustic, classification, interferometry

A04-025 TITLE: Embedded Smart Sensor Electronics for Remote Sensing

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Homeland Security Office, Picatinny

OBJECTIVE: Design and build an innovative high-speed processing smart unit for remote sensing.

DESCRIPTION: The Homeland Defense and Homeland Security have become more complex for the law enforcements and safety agencies ever since the 9/11 attacks. Terrorism threats are becoming one of the greatest concerns among nations, causing fear and chaos. Complete situational awareness is paramount for the crime fighter to identify and react quickly to threats. Sensor system advancements are enabling the crime fighter to detect a variety of threats, such as intruder movements and chem/bio threats. However, most sensor systems are still limited in portability due to the difficult bandwidth requirements for wireless transmission, limiting the range for remote sensors and increasing cost. This SBIR seeks to enable the remote deployment of a variety of sensor technologies by providing miniature high-speed processing and algorithms at the sensor to reduce the bandwidth, power, and size required by filtering the data to only the necessary intelligent information that is desired to be forward to the warfighter. Existing algorithms are processed on large, power-hungry processors that make remote deployment time consuming and difficult. Furthermore, typical sensors are single modal, only processing an algorithm devoted to a single sensor. With the recent advancements in high-speed processing technology a small processor can be developed to enable remote tactical sensing. The solicited, innovative approach should provide a general-purpose platform that is capable of processing complex sensing algorithms from multiple sensor modalities in an extremely small form factor. This SBIR also includes the development of multi-modal algorithms on a single processor. It is expected that this SBIR will result in a breakthrough processing technology that can be placed behind any passive or active sensor, such as video, thermal, acoustic, seismic, chemical, biological, etc.

PHASE I: Conduct preliminary research and design a small, low-cost, high-speed processing smart engine to execute a variety of onboard sensors. Prove the design through precooling at least two different sensors simultaneously with a built-in wireless device.

PHASE II: Develop an integrated prototype and perform preliminary field tests with multiple sensors.

PHASE III DUAL USE APPLICATIONS: This general purpose processing technology can be used in a variety of military remote sensing applications including program that require small electronics such as UAV, UGV, etc. This small commercial electronics can be used for a variety of homeland security applications such as border monitoring, airport security, high-value facility protection (power plants, chemical plants, water plants, etc.), and transportation security (subways, trains, highways, bridges, tunnels, etc.).

REFERENCES:

KEYWORDS: Sensors, high-speed processing, surveillance, algorithm, image processing, ATR, target tracking and location, acoustic sensors, chem/bio sensors, video sensors, sensor fusion

A04-026 TITLE: Confined Space Blast Wave Measurement
TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons
ACQUISITION PROGRAM: PEO Soldier and PEO Ammunition

OBJECTIVE: Develop a capability to measure and plot blast waves in an enclosed space.

DESCRIPTION: Enhanced blast explosives are becoming more widely proliferated throughout the world. Such explosives are difficult to characterize, especially when used in enclosed structures. Reflective effects from the walls, floor and ceiling are difficult to analyze at best with conventional directional blast probes. We need a way to measure, plot and analyze the blast characteristics of an explosion.

PHASE I: Design a system that can measure, characterize and potentially render a 3-D model of the blast inside an enclosed space. This measurement should be able to take into account all the blast reflections in a 3 dimensional space. The sensor system should be independent of the structure, and may contain a network of many sensors. The recorded data must be recorded somehow and would ideally output to a software program, not only indicating peak pressure, and duration at what time, but also plot the individual waves and reflections in a 3-D display. Deliverables will be a functional block diagram, sensor design and a list of hardware and software to be utilized, well as the final report.

PHASE II: Fabricate the system and integrate with data collection software and modeling tool. Perform demonstration of capability at Army facility. Deliverable will be a prototype system for further Army evaluation.

PHASE III DUAL USE APPLICATIONS: Primary use is for military evaluation of explosives and their application in specific scenarios. Other uses include power plant, chemical factory and manufacturing facility design to take industrial accidents into account. Also could be used for civilian structure design to identify weak members to an internal explosion, possibly terrorist generated, to design for structural stability.

REFERENCES:
1) http://www.aop.hw.ac.uk/Projects/sensor12.htm
2) http://www.iop.org/EJ/abstract/0957-0233/11/2/302

KEYWORDS: Blast measurement, probe, sensor, blast, wave, reflective interference

A04-027 TITLE: Multi-Tasking Assessment for Personnel Selection and Development
TECHNOLOGY AREAS: Human Systems
OBJECTIVE: “Multi-tasking” characterizes work in which an individual engages in the activities of two or more tasks, with each task having its own goals. There are a number of variables that likely contribute to an individual’s capability to perform effectively in work settings that require multi-tasking. There are also variations in the work conditions that create requirements for multi-tasking. This research will propose a set of variables that likely contribute to an individual’s multi-tasking capability and that, if appropriately measured for job candidates, would enable organizations to select or develop new members for effective performance of jobs that vary in multi-tasking requirements. This research will identify and establish the feasibility of an approach for measuring the proposed variables. As appropriate, the research will construct the measurement methods and assess their validity and operational potential.

DESCRIPTION: Transformation of the U.S. Army (U.S. Army, December 2001, 2002; U.S. Army Training and Doctrine Command, 2002) offers possibilities of dramatic change in Army technology, organization, and operational concepts. These socio-technological changes will affect the work of the individual Soldier (Ford, Campbell, Campbell, Knapp, & Walker, 2000; Sager & Russell, 2003). Emerging digital systems offer the likelihood of changing a Soldier’s work and workload in ways that increase the number and variety of assets under the Soldier’s control, the Soldier’s geographical and temporal span of control, and the Soldier’s overall situational awareness. Changes in organizational structure will potentially reduce the number of Soldiers in a unit, with this smaller number of Soldiers using emerging systems to achieve force capabilities that meet or exceed the capabilities now met only through larger staffing levels. Soldiers, for example, will control units to operate multiple robots/unmanned vehicles, with the Army seeking designs and personnel to increase the number of robots operated by a Soldier. With smaller units, task requirements previously reserved for leaders or senior Soldiers will possibly be “pushed down” to relatively junior or even entry-level Soldiers. Operational concepts envision versatile units that perform continuously and can adjust to the demands of full spectrum operations. As our current war on terrorism shows, such operations are often complex and require Soldiers who can balance and meet, within the context of a single operation, goals associated both with defeating the enemy and with building relationships for nation development. The Army requires Soldiers who can engage in multiple tasks without degradation in any task and with minimal requirements for training or planning for mission, to include workload, requirements.

Overall, “multi-tasking” characterizes work in which an individual engages in the activities of two or more tasks, with each task having its own goals (Wickens & Hollands, 2002). There seems to be some variation in the job conditions that create multi-tasking requirements. On the one hand are the conditions like those involved in operation and use of multiple robots to close with, engage, and defeat an opponent. In this case, the conditions defining requirements for multi-tasking are reminiscent of the multi-tasking requirements in jobs like air traffic controller. On another hand are conditions that are less defined by operation of and decisions about objective entities. An example of these conditions can be found in casualty evacuation activities in which a pilot or ground Soldier balances requirements for casualty rescue with the requirements for safety from enemy fire. Such conditions can impose high-order cognitive processes, for example, decision-making about courses of action that reduce enemy threat but that also maintain friendly relations with local nationals. Organizations, like the U.S. Army, need to acquire and develop members who are able to perform effectively under the multi-tasking requirements of current assignments and, in addition, are also able to grow for performance in settings that vary in multi-tasking requirements.

Thus, the issues here include specification of the variations in conditions creating requirements for multi-tasking, the personnel attributes enabling successful performance under these variations, and methods for measuring the potential or actual capacity to perform over the sets of conditions defining variations in multi-tasking requirements. Recent air traffic controller research (Hattig, 1999) has taken into account cognitive and information processing requirements. Research (Chiles, Jennings, & West, 1972; Chiles & West, 1974) has shown that scores on tests of the multi-tasking requirements specific to a job/job type are useful for predicting effective performance of the job and, by implication, for selection of and feedback to trainees. Research has also suggested the potential contribution of personality characteristics (Hattig, 1999) to multi-tasking performance. Relatively recent research has examined polychronicity, or individual differences in preference to engage in multiple tasks at the same time. Polychronicity research has sought evidence on construct validity and predictors of this preference (Conte & Jacobs, 2003; Conte, Rizzuto, & Steiner, D.D., 1999; Kaufman-Scarborough & Lindquist, 1999).
PHASE I: In Phase I, the researchers shall use the past research literature to identify a set of individual difference variables that are (1) important to effective performance of the multi-tasking requirements of the jobs held by first-term enlisted Soldiers and (2) likely useful in the selection or development of new organizational members. The researchers shall also identify an approach for validly measuring the selected variables and establish the feasibility of the identified measurement approach for use in an operational setting. Using this background, the researchers shall propose a plan for construction of the measure(s) included in the established approach. The plan shall clearly specify the variable(s) proposed for measurement and the rationale for targeting the variable(s). The plan shall also propose the measurement approach, the rationale for the approach, and the basis for expected feasibility. The plan shall propose the research activities needed to complete construction of the measures. Finally, the researchers’ proposal shall include a plan for testing the method to determine its validity for the selection of new organizational members and its potential for use in operational selection environments.

PHASE II: In Phase II, the researchers shall execute the plan developed in Phase I. In accordance with the Phase I plan, the researchers shall construct measures ready for validation and for assessment of their operational potential. As practical, the validation test shall include Soldiers in their first term of enlistment. The test shall be designed and executed for conclusions about the range of multi-tasking requirements that the measures are expected to predict. Test results shall be used, as appropriate, to revise/recommend measures for further assessment as operational prototypes.

PHASE III: Civilian organizations share many of the characteristics of today’s military. Thus, civilian corporations and businesses are also changing with their employees working within contexts shaped by the types of the digital and information systems being infused into the Army. A relatively longstanding issue has been the increasing transferability and blending of military and civilian jobs, with military jobs becoming more similar to civilian jobs. Indeed many, but certainly not all military jobs, have components with civilian counterparts. Thus, the assessment method has strong dual use potential to the extent that it enables personnel selection and development for effective performance either across job types or in multi-tasking conditions prevalent in civilian organizations. In Phase III, the researchers will test the generalizability of the method to civilian jobs for fuller development of a robust marketing strategy.

REFERENCES:
A04-028  TITLE: Emotional Intelligence Tools for Personnel Selection, Training and Development

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Validated measures to assess emotional intelligence and materials to train and develop related competencies.

DESCRIPTION: Broad societal changes have influenced the nature of work within both the military and the civilian sector and carry implications for the identification and development of skill sets required to function effectively under high-stress and other emotionally-laden circumstances. These conditions are sometimes associated with interpersonal transactions but may also emerge as reactions to fast-paced, high-demand events and situations. Since 1990, emerging psychological conceptualizations have theorized that the ability to perceive, manage, express, and utilize emotions has profound ramifications for understanding and supporting human cognition and performance, and the utilization of this information has helped support the positive psychology zeitgeist. Emotional intelligence (EI) is defined by these four abilities (the perception, management, expression, and utilization of emotion), is separate from general cognitive ability, and is quantified by the covariance among these abilities (i.e., factor scores extracted from separate measures of these four abilities). Conventional approaches to assessing EI have been largely limited to the consideration of easily-observable, self-report behavioral tendencies, while maximal performance measures of EI have been associated with more specific mental health criteria. Data collected with these EI measures demonstrate the importance of this ability to daily functioning and strongly suggest that new approaches are required to fully leverage knowledge and skill conceptualizations of emotional intelligence and apply these conceptualizations to personnel selection, training, and development systems. Although the military has not leveraged performance-based measures of EI, the stressful, intensely personal nature of many Army tasks and occupations suggest that developing and utilizing measures of emotional intelligence to support personnel selection, training and development within the Army will enhance performance. Furthermore, recent workshops sponsored by the US Army Research Institute (ARI) and Educational Testing Service (ETS) have focused on the potential importance of this capability to personnel management, and the Select21 project acknowledges the importance of EI-related constructs but lacks emphasis on the development of direct measures to support selection and development. As a basis for these approaches, more must be known about the nature and strength of the relationship between EI skills and knowledge, and the performance of Soldiers and civilians in high stress, emotionally demanding jobs. A comprehensive personnel management and training system would include: (1) the capacity to identify jobs where EI is a key factor in effective performance, (2) the capacity to assess an individual’s ability to recognize, express, react and manage emotions associated with these interpersonal events and emotionally-laden circumstances, and (3) the capability to develop these abilities and train the required skills and knowledge based on a thorough understanding of experiences supporting the growth of related knowledge and skills.

PHASE I: Describe in full detail the approach to be used to identify EI skills, knowledge and events relating to performance in high-stress military and civilian environments. Produce a comprehensive plan for using this approach to support the identification of jobs with EI requirements, and prediction and development of job performance. Many factors can influence performance including emerging systems, new doctrine, leadership, new training, new missions, and external environmental factors (e.g., social changes, geopolitical factors) and their impact on the individual’s level of readiness. Because of the unusual nature of the performance being assessed in this context, novel approaches may merit consideration. The desired product is a set of maximal performance measures to be validated against job-related criteria and an approach to train and develop the characteristics underlying performance on those measures.
PHASE II: Develop methodologies based on the approaches specified in Phase I and apply them to up to three emerging occupations that are projected, based on criteria specified in Phase 1, to be influenced by the capacity to recognize and manage one’s emotional state. The occupations will be identified in discussions with Army Research Institute (ARI) representatives and will be ones for which sufficient job analysis information exists to provide a basis for determining the relative importance of EI, and development and validation of new performance measures. Identify those components of the jobs for which the approach is appropriate and develop performance measures for these components. Validate the proposed tests and developmental approaches using medium-size samples of individuals (100 to 500) to determine the utility of these measures and the feasibility of developing related skills, knowledge and abilities.

PHASE III DUAL-USE APPLICATIONS: Currently, personnel selection, promotion, and training decisions are being made based on measures of individual performance, or expected individual performance, on tasks or other job components which may not fully represent occupational performance requirements. The development of methods to address performance on future job requirements provides the capability to keep selection and training tools more current, to more effectively use critical personnel resources and to develop a more adaptive and effective organization. These methods are equally applicable in governmental and private realms, and the benefits generalize to both contexts as well. A company with such a products would be well positioned in the human resource management field for related civilian applications. Phase III will apply these products to corresponding civilian sector occupations to generalize finding emerging from the military analyses.

REFERENCES:

KEYWORDS: Emotional Intelligence
identified as key dimensions for the Army’s Future Force (Campbell & Knapp, 2001; McCloy, Putka, Van Idkekinge, & Kilcullen, 2003).

These findings have generated much interest in using temperament measures for personnel selection, but their use has been curtailed due to concerns about item transparency and fakability. In a selection context, for example, the motivation to provide accurate self-reports may be displaced by motivation to answer in a way that would appear favorable to those making the hiring decisions. Research comparing responses to self-report temperament/personality items across testing situations has clearly shown that job applicants increase their scores, as compared with research participants, when there are incentives to make a positive impression. (e.g., Rosse, Stecher, Miller, & Levin, 1998). As a result of these motivational factors, when temperament measures are used in the hiring process, the result can be highly inflated scores, which are of little or no value to selecting officials.

Approaches to detect and correct scores for faking using social desirability and impression management scales, have worked to some degree (e.g., White, Young, Rumsey, 2001), but problems remain with this approach (Christiansen, Goffin, Johnston, & Rothstein, 1994). Consequently, much interest has shifted to preventing faking by using new item response formats and scoring methods. An example of such a format involves the construction of multidimensional forced-choice items. Recent research (White & Young, 1998; Young & White, 1998) suggests that the multidimensional forced-choice format can reduce score inflation due to faking, as compared with traditional, single stimulus (statement) items.

However, the use of multidimensional forced-choice inventories in applied settings has been limited – perhaps in part - due to concerns about ipsativity. Some quasi-ipsative scoring heuristics have been introduced to overcome ipsativity (White & Young, 1998). However, it is unclear how well such quasi-ipsative measures approximate the normative measurement needed for making interindividual comparisons in a personnel selection context.

What is needed to overcome these limitations is to develop a formal mathematical model for responding to multidimensional forced-choice items and an item-format and associated scoring algorithm that produces normative instead of ipsative scores. Multidimensional item response theory (IRT) models would appear to have considerable promise for providing such a framework, although other approaches should also be considered. Importantly, the development of a formal model would allow transitioning to computer-adaptive assessment technology, which can simultaneously reduce testing time, lower measurement error, and increase the accuracy of test scores. The efficacy of computer-adaptive assessments in the temperament/personality domain represents a significant challenge and has been, for the most part, unexplored to date, although computer-adaptive assessment is now an integral part of cognitive aptitude testing in the military. Consequently, there is a need for a measure that:

- contains large item pools assessing important temperament facets;
- can be administered efficiently by an computerized adaptive algorithm or as a fixed-length, paper test where computer administration is not feasible
- uses fake-resistant items and scoring approach.

PHASE I: Phase I will produce a formal model for developing and scoring fake-resistant items. In the process of model development, the optimal format(s) for item presentation shall be determined. Using simulation studies it must be shown that the scoring algorithm can recover known trait scores, representing different personality dimensions, with a high degree of accuracy, so that interindividual comparisons are possible. In addition, Phase I will produce a report identifying broad and narrow temperament/personality traits that are expected to be useful for selection decisions in military and civilian occupations.

PHASE II: Phase II will involve the development of fixed-item and computerized-adaptive measurement system for broad and narrow traits as well as its evaluation and validation – based on the optimal item format(s) identified in Phase I. A minimum of five constructs will be identified for measure development. Validation shall be done at various ranks and for various purposes within the Army. The goal will be to achieve construct and predictive validity in research settings, followed by use in an operational setting, where a high degree of faking is likely. In this phase, comparisons will be made between the criterion-related validity and reliability of the new measure and traditional approaches.
PHASE III DUAL USE COMMERCIALIZATION: The development of methods for assessing temperament using fake-resistant items will represent an important advancement in the personnel selection. Providing an associated computer-adaptive measurement system will increase measurement accuracy and reduce testing time. These methods are equally applicable in the military and private-sector realms and benefits generalize to both contexts. A company with such products would be well positioned to make a major advancement in civilian applications. Phase III will apply these findings to civilian occupations to generalize findings emerging from the military applications.

REFERENCES

KEYWORDS: Individual Motivation, Personality, Faking, Computer-Adaptive, Measurement, Assessment

A04-030 TITLE: Shared Understanding Across Levels of Command

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop an assessment tool and training approach for optimizing the extent to which a common framework of goals and understanding is shared, to the necessary extent, across levels of command.

DESCRIPTION: U.S. missions are increasingly reliant on multi-service, agency, or national coordination and cooperation to achieve success. Critical to success in these missions is the clear communication of intent and goals as well as the maintenance of a common understanding of the ongoing situation across levels of command, and across service and agency boundaries. Command intent conveys to subordinates the overall goals and effects desired by the Commander. Command intent as it is transmitted down the chain of command, however, may be understood through the concept of hierarchical goal structures. The theater commander conceives a strategy for accomplishing an overall goal, communicating this overall goal to his or her subordinates along with their roles in its accomplishment. In turn, each of those subordinates communicates down through the chain of command the Command Intent and provides goals and direction to the level of command beneath them. Although the goals at the lowest level of this hierarchy (e.g., patrol and secure Baaka St.) may not resemble the highest level goal (e.g., conduct stability operations in the Northern sector of the country), the goals are inherently related and consistent. However, to the extent that command intent is misunderstood by subordinates in part or in whole, inconsistencies will exist between commander and subordinate. As information is evaluated by commanders at all levels of the chain of command, it is imperative that leaders throughout the chain of command are synchronized in terms of their
understanding of the command intent, using that as the basis for interpreting and acting upon information as it is gathered.

This research will link together for the first time prior research from the topic areas of shared cognition in teams, specifically the measurement and conceptualization of shared mental models and team situational awareness, with research related to hierarchical goal structures. Prior research on shared cognition has focused within a single level of the chain of command and has not dealt with the changes in focus, goals, available information, and differing requirements that occur across levels of the chain of command. The focus of this research to produce an assessment tool to index the extent of shared understanding of Command Intent across levels within the chain of command. This assessment tool must account for the fact that leaders at different levels within the chain of command will have different, though synchronized, goals and will thus have a somewhat different understanding of the Command Intent as a result. In addition to the development of an assessment tool that can be used to detect sharedness and lack of sharedness, this research should also produce a set of training or job aids that can be used by Commanders in the field to identify and remove discrepancies in understanding of Command Intent within the chain of command. The extensive research relating to assessing shared mental models provides a sound basis for approaching the assessment problem. The most difficult, and perhaps most critical, challenge will be assessing sharedness across levels of the chain of command, and the corresponding levels of the goal structure.

PHASE I: Integrate the idea of hierarchical goals into the conception of the "sharedness" in terms of shared cognition, specifying the extent to which and how "sharedness" is applied across levels within the goal structure. Identify potential methods of assessing and indexing the extent to which command intent is shared across levels within the chain of command. Identified methods should be able to account for the nature of the differing (but linked) goals of the leaders at different levels within the chain of command. Identified methods should be able to be used by commanders to identify when and where there is a deficiency in ‘sharedness’ within the chain of command. Identify potential methods for developing ‘sharedness’ where deficiencies have been identified. Identified methods should be useful in the field during high tempo, high intensity engagements. Identified methods should not require extensive time or capabilities that will not be available to leaders in the field.

PHASE II: Develop and validate one or more methods of assessing "sharedness" in a way that accounts for multiple levels of nested goals. Develop one or more methods or means of aligning misaligned goals across levels of command that Commanders can potentially use as a job aid. Develop one or more training or development methods intended to increase “sharedness” of understanding across levels of command using the developed methods for assessing “sharedness” to validate the chosen method(s).

PHASE III Dual use Commercialization: As work becomes more complex, organizations are increasingly relying on teams as a primary unit to successfully accomplish it. Teams are able to handle workloads that overwhelm a comparable number of individuals working on their own, by allowing workload shifts in response to environmental demands, sharing capacity for remembering or processing information, and providing emotional and motivational support within the team. As teams are increasingly used in organizations, the use of multiple, hierarchically arranged teams and the integration of multiple organizations into teams is also increasing. The assessment and training methods, as well as the basic knowledge, developed here will be of particular use to assist organizations in structuring, staffing, and training these teams for maximal performance. Similarly, The training methods developed here would have broad application within all military services, whether units are engaged in Joint or Multinational actions or not, to enhance the alignment of the chain of command around commander intent and the extent to which all levels of the chain of command are able to maintain a common understanding of events as they unfold.

REFERENCES:
KEYWORDS: Commander's Intent, Mission Command, Command & Control, teams, team leader, shared cognition, shared understanding, leader training, leader development, team training, multinational teams, joint services

A04-031 TITLE: Trust in Temporary Groups

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop a testable framework to determine the extent to which Swift Trust (Meyerson, Weick, & Kramer, 1996) is developed within Future Force units and to relate the level of trust within a unit to unit climate and measures of unit performance. The framework should also investigate the extent to which swift trust evolves into more traditional unit trust. Measures should be objective and account for various underlying constructs such as vulnerability, uncertainty, risk, and expectations. The product will be used to aid units when deployed at the tactical level. Ultimately, the product will be applied to those units operating at the Joint and Multi-national Force levels, advising the leadership as to steps that may be taken prior to deployment to encourage trust between/among hastily formed teams.

DESCRIPTION:
Trust is generally defined as “an expectation that one can rely on another person’s actions and words and that the trustee has good intentions towards the trustor.” Basically, trust is based on the expectation that others will behave as expected (Jarvenpaa, Knoll, & Leidner, 1998). Swift trust is a specialized type of trust formed in temporary systems. As a rule, trust is thought to be something which forms with time, as the actors in a system get to know one another. The army indicates:

Team building produces trust. Trust begins with action, when leaders demonstrate discipline and competence. Over time, subordinates learn that leaders do what they say they’ll do. Likewise leaders learn to trust their subordinates. That connection, that mutual assurance, is the link that helps organizations accomplish the most difficult tasks. (FM 22-100, 6-139)

However, from the direct leadership level up, the Army mission compels soldiers and units to work together on a temporary basis. From firefighting and flood evacuation missions in our own country to much larger Joint Operations overseas, soldiers and units who have never trained together must operate as though they have previously been working and training together. Thus, it is important to understand the circumstances under which swift trust is formed and the circumstances which impede the process. Meyerson, et al. (1996) define swift trust as a specialized form of trust formed in hastily created groups that are usually temporary in nature. Several factors inherent in temporary groups are expected to be relevant to the formation of swift trust (p. 169):

1. Participants with diverse skills are assembled to enact expertise they already possess.
2. Participants have limited history of working together.
3. Participants have limited prospects of working together again in the future.
4. Participants are part of limited labor pools and overlapping networks.
5. Tasks are often complex and involve interdependent work.
6. Tasks have a deadline.
7. Assigned tasks are nonroutine and not well understood.
8. Assigned tasks are consequential.
9. Continuous interrelating is required to produce an outcome.

There are several factors underlying traditional trust which may also be relevant to the formation of swift trust and should also be investigated and to possibly be included in the model. Zucker (1986), identifies the constructs as characteristic-based trust, process-based trust, and institutional-based trust. Newell and Swan (2000) identify similar factors as competence trust, companion trust, and commitment trust. Competence trust is the level that one actor feels they can depend upon another in order to perform the job they are expected to perform. Perception of
competence can be gained by personal reputation or institutional affiliation, among other things. Thus the level of competence trust one actor has for another can precede the actors even meeting in person. This level of trust develops quickly and can dissolve quickly also since the pre-conceptions of competence may be inaccurate or not immediately proven. Companion trust is the level to which each actor perceives the other motivations as stemming from goodwill. The level of benevolence an actor perceives takes time to develop as one gets to know another. Just as this type of trust takes time to develop as actors get to know one another, it also is longer lasting as actors are seemingly less likely to attribute underhanded motives to someone they know. Commitment trust is also known as contract trust, it depends upon all actors understanding their roles in completing the task at hand. Commitment trust works as long as the actors implicitly have ‘the contract’ to rely on. It is somewhere between Competence and Companion trust as far as resilience is concerned. Actors do not have to believe in the goodwill of others to get the job done, nor do they even have to believe the other party is competent, since the contract is always there to fall back on.

PHASE I: Phase I consists of making a determination of the potential of measures of traditional and swift trust. This involves identification of constructs related to trust including, for example: vulnerability, uncertainty, risk, and expectations. The relationships between the constructs and their relationship to the amount of trust in a group will be assessed. As part of the plan, access to a study population will be obtained, as demonstrated by letters of support from key military personnel, and human studies approval will be sought.

PHASE II: In this phase the efforts achieved during phase I will be further refined and exploited. The final product, the trust measure, will be piloted for relevance, interest, and applicability in ‘real world’ situations. The relationships between constructs and their relationship to traditional and swift trust will be further statistically modeled and tested. Specifically, a measure of trust will be developed for use by military populations and the relationship between trust and unit readiness and effectiveness explored and methods for increasing trust levels tested. Additionally, the evaluation design and sampling plan will be finalized for testing the intervention in Phase III.

Phase III DUAL USE APPLICATIONS: The intent of this research is to be able to provide military leaders with measures of unit trust as well as possible proscriptive actions that may be taken to improve unit trust levels. The measures will be refined for ongoing military applications and modified for civilian applications where populations are quickly formed into working groups (e.g. firefighters, police officers, personnel in non-governmental organizations deployed to hazardous or underdeveloped regions).

REFERENCES:
1). Army Leadership. FM 22-100, Washington, DC; Headquarters, Department of the Army.

KEYWORDS: team, trust, trust development, maintaining trust, leadership


TECHNOLOGY AREAS: Human Systems

OBJECTIVE: New practical implementations of complex adult development theories of wisdom, such as those proposed separately by Kegan, Baltes, and Sternberg, must be united with new internet delivery and intelligent agent technologies to provide powerful tools for self development and 360 assessment to help grow leaders faster and smarter.
DESCRIPTION: Leader development systems must be optimized to train and educate leaders capable of operating as part of a Joint Team at war—leaders who possess the wisdom to extend their expertise and values beyond service interests into a Joint and Expeditionary Mindset. The Army’s systems will educate and reward leaders with the mental agility to thrive at all levels in modern war. We must develop in our future leaders the right mix of unit, staff, and command experience, and the abilities to profit from that experience to meet the current and future leadership requirements of the Army and the Joint Force. Our leader development systems must be re-designed for the current and future strategic environment and promote leader growth. For such tasks, substantive improvements in theoretical understanding of strategic vision and wisdom and new assessment technologies that incorporate wisdom, ambiguity and uncertainty are urgently needed. To develop and train agile and adaptive leaders able to conduct simultaneous, distributed, and continuous operations; self-, peer-, and superior-assessment technologies must illuminate the most complex aspects of pragmatic expertise, including wisdom and values. New practical implementations of complex adult development theories of wisdom, such as those proposed separately by Kegan, Baltes, and Sternberg, offer unique insight into the Army’s LDRSHP (Loyalty, Duty, Respect, Selfless service, Honor, Integrity, and Personal courage) values as aspects of wisdom. They also offer effective assessment instruments that may be streamlined and united with new internet delivery and intelligent agent technologies to provide powerful tools for self and 360 assessment to help grow leaders faster and smarter. Kegan argues that most higher-level managerial and leadership positions require a stage 4 conceptual vision for success (Kegan, 1994). If this is true, then progressing from stage 2 through stage 3 to stage 4 is critical to the growth of autonomous Army leaders and professionals (Forsythe et al., 2002) of the sort capable of exercising sound judgment in the face of the complex, ambiguous, and rapidly changing situations that require wisdom. Baltes (1993) defines wisdom as expert—level performance in the pragmatics of life, and Sternberg (1998) describes it as the application of tacit knowledge mediated by values through a balance among personal, interpersonal, and extrapersonal interests. All three have created effective assessment instruments of various length and complexity. However, some of the instruments, such as Kegan’s semi-structured interviews require many hours of expert interviews and analysis in scoring that need to be adapted extensively before it can be routinely applied to measure wisdom. The use of automated intelligent agent technologies should not only reduce the scoring time dramatically, but also enable the widespread, distributed self-assessment of wisdom. Leader assessment, training and development will nest within the Joint National Training Capability and accurately reflect the realities of the contemporary operating environment for speeded self-development. The technology must also be useful for our training institutions to better enable commanders to develop subordinate leaders.

PHASE I: Develop a new overarching framework for wisdom that applies to Army officers and leads to pragmatic assessment instruments that can be applied with intelligent agent technologies. Describe the outline of this framework in the Phase I proposal. Produce an experimental prototype demonstration of an assessment instrument that incorporates and extends current theoretical frameworks for assessing wisdom and use it in a research effort with at least 30 officers or professional adults to demonstrate its internal and external reliability. It must incorporate the attributes described above sufficiently well that the feasibility and utility of a fully functional system (capable of providing accurate self development feedback to leaders on the status of their adult development of pragmatic wisdom using internet and agent technologies) can be evaluated by both informal examination and formal testing.

PHASE II: Produce a completely functional prototype system capable of trial use and user-centered evaluation and redesign for implementation in the Future Force with any electronically transmitted medium. The Phase I experimental prototype must be refined incrementally in a series of research efforts to validate the proposed assessment instruments and intelligent agent scoring technologies using medium-size samples of individuals (100 to 500). Phase II will focus on developing guidelines and approaches to growing wisdom through self development and begin the more complex effort of going beyond self development.

PHASE III DUAL USE COMMERCIAL POTENTIAL: The system will be valuable for use by all leadership sensitive enterprises: industrial management, education, military, and intelligence organizations, and should be actively marketed there.

REFERENCES:


KEYWORDS: wisdom, assessment, wisdom assessment, leader development systems

A04-033 TITLE: Novel Solid State Reflective Imaging Devices for Flexible Display Applications

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: Henry Girolamo, Natick Soldier Systems OFW Displays POC.

OBJECTIVE: Develop new breed of robust solid-state reflective imaging devices utilizing electrochromic (based on the redox chemistries of metal nanoparticles), electrophoretic, liquid crystals, and other devices, including full color. The novel reflective imaging devices will be inexpensive and simple to manufacture. These devices will have applications that include flexible displays.

DESCRIPTION: The purpose of this solicitation is to explore nanotechnology for electrochromic, electrophoretic, and liquid crystal device development. This research will enable the creation of new families of solid-state flexible displays, adjustable optics, filters and shutters. The metal nanoparticle based devices will require no organic synthesis and will be unaffected by the presence of oxygen and moisture during fabrication. This will result in simple and inexpensive device fabrication methods compared to the fabrication methods of current state of the art devices. Novel properties, i.e., electrical, spectral and structural, will be determined for the novel devices which may show unique characteristics due to the fact that metal nanoparticles have been proven to exhibit size dependent properties that vary widely. These size induced characteristics are not intuitive; therefore, theory is not always an adequate predictive tool for confined metal nanoparticle characteristics. These characteristics are ascertained, more often then not, after extensive experimentation.

The size, shape and concentration of metal nanoparticles are known to affect the overall observed electromagnetic properties of the materials these particles are dispersed whether the media is in the form of a solution, gel or solid. For instance, spherical particles usually exhibit a single absorption band that increases in intensity and undergoes a red shift as the particle size increases. Conversely, as spherical particles decrease in size the observed absorption band blue shifts and decreases in intensity. Cylindrical particles, on the other hand, exhibit two absorption bands (radial and translational modes) that follow the same size/absorption trend as spherical particles. Utilizing this reversible redox dependent process, the contractor shall design an ECD based on the reduction of metal ions to form metal clusters/particles which, upon the application of an oxidative potential, the clusters/particles are oxidized back to metal ions. The device should be transparent in the bleached state (oxidized state) and colored in the reduced state. The aim of this research is to develop and characterize a solid-state electrochromic device based on the reversible formation of metal clusters/particles in a solid state matrix. The device should be inexpensive to fabricate and impervious to environmental conditions while optimizing device switching speed.

PHASE I: The contractor shall execute methodologies outlined in the awarded proposal which lead to feasibility studies for the fabrication of prototype solid-state Reflective Imaging Devices based on Electrochromics, electrophoretics, liquid crystals of other related technologies. Spectral responses, switching potentials and switching speeds will be reported.

PHASE II: Building on the feasibility studies in Phase I, the contractor shall demonstrate the Reflective Imaging Devices with optimized power requirements, switching speeds and lifetimes. The Reflective Imaging Devices developed under the Phase II will be subject to basic MIL-STD-810E characterization.
PHASE III: Development of robust Reflective Imaging Devices based on metal particle based electrochromics, electrophoretics, or liquid crystals will allow for applications of Reflective Imaging Devices for such application as flexible displays in the automotive, construction, aerospace and computer industries.

REFERENCES
5) E.W. Forsythe et. al SPIE AEROSENSE PROC, Orlando FL, April 2002.

KEYWORDS: Electrochromic devices, nanotechnology, metal nanoparticles, solid-state, polymer, matrix, electrophoretics, liquid crystal

A04-034 TITLE: Multifunctional Ceramic Barrier Coatings for Si-Based Ceramic Components

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop innovative, multifunctional ceramic barrier coating concepts to significantly improve Si-based ceramics temperature capability in heat flux, erosion, oxidizing and water vapor containing combustion gas environments

DESCRIPTION: The advanced propulsion engines for Future Combat Systems (FCS) may be designed by utilizing high strength and lightweight Si-based ceramic hot-section components to meet engine high efficiency, high power density, compactness, and low emission goals. Multifunctional ceramic barrier coatings will play a crucial role in the ceramic engine systems because they are of necessity to provide vital thermal, environmental, and erosion protections for the Si-based ceramic components in the harsh combustion gas environments at the temperatures that sometimes can exceed 1482° C (2700° F).

This SBIR solicitation seeks innovative multifunctional ceramic barrier coating concepts and advanced coating processing techniques to meet future engine performance goals. In particular, high temperature capability, high toughness, low thermal stress, and erosion resistant ceramic barrier coating concepts for low thermal expansion Si-based monolithic ceramics and ceramic matrix composites (CMCs) will be developed and demonstrated. Advanced processing techniques may also be developed for realizing the multifunctional barrier coatings in thin layer configurations with embedded harsh environmental sensors for complex-shaped turbine and diesel engine components. Innovative approaches to incorporating coating health diagnostic and self-repairing functions that can significantly improve the component temperature capability and durability may also be developed in this SBIR effort.

PHASE I: Develop advanced ceramic barrier coating material concepts and demonstrate the coating feasibility for Si-based ceramics. Demonstrate coating material performance and stability in the engine relevant oxidizing and water vapor environments at temperatures up to 1482° C (2700° F).

PHASE II: Integrate the coating functions through advanced coating processing approaches. Demonstrate the multifunctional coating feasibility with potential embedded sensor capabilities for the Si-based ceramic components. Downselect a coating system consisting of a novel high temperature capability bond coat and a low thermal stress and high strength thermal-environmental barrier coat with improved functionality, erosion resistance and thermal cycling durability.

PHASE III: The coating technologies developed under this SBIR can be widely used in the Army and other DoD vehicle propulsion engine applications. Potential commercial applications include aircraft propulsion, and electric power generation, ceramic diesel and gasoline internal combustion engines.
REFERENCES:

KEYWORDS: Advanced propulsion technology, thermal and environmental barrier coatings, erosion resistant coatings, functional coatings, thermal cycling resistance, embedded environment sensors

A04-035 TITLE: Integrated Multi-Channel MHz Speed Fiber Phase Shifters for Free-Space Laser Communication Transceiver Systems

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: Future Combat System

OBJECTIVE: The development of compact Gbit/sec bandwidth Army free-space laser communication systems requires low-loss multi-channel integrated beam combiners with fast low-voltage phase shifting and amplitude modulation capabilities. These new types of phase shifting devices can be used for various Department of Defense (DOD) applications including laser communication, synthetic aperture optical imaging, laser designation, and directed energy systems for phase locking of multiple optical receiver and transmitter systems. The objective of this program is to integrate in a single solid-state device the capability to launch a 1550 nm laser beam, with a low-loss split of the input beam into multiple parallel channels, and with individual control of the beam phase and amplitude in each channel. The integrated phase shifter should provide the capability for operation with a high-power wave propagating in one direction (from a single-mode input to multiple phase shifting outputs), and with orthogonally polarized low-power waves which propagate in the opposite direction (from multiple single mode inputs to a single output). The integrated multi-channel device should introduce the same phase shifts into the counter-propagating waves, and should efficiently separate the counter-propagating waves at the device input. The specific objectives of this program are to develop a new generation of fiber-optic multi-channel phase control devices that can be used in various opto-electronic laser communication, imaging and laser beam formation systems.

DESCRIPTION: The solid-state device developed under this program should implement the following functions: at its input, separate the high-power (>25dBm-30dBm) outgoing beam launched into a single mode fiber from the low-power (<-20dBm) counter-propagating beam, with less than 50 db crosstalk between beams; provide low-loss multi-channel beam splitting (for the outgoing) and beam combining (for the counter-propagating) for waves having common optical paths; implement fast (MHz rate), large dynamical range (grey-scale >9bit), large amplitude (>4p), and low voltage (<20v) controllable phase shifting in each of the channels, with simultaneous control of attenuation coefficients in each channel. An important consideration is to reduce crosstalk between the channels.

PHASE I: Propose a design for a multi-channel controllable phase shifter with a small number of channels and low-power input. Perform a feasibility analysis of anticipated system performance.

PHASE II: Integrate the design with the large number of channels, and increase the contrast ratio between the counter-propagating waves. Develop and demonstrate commercial and military applications, and leverage market opportunities.

PHASE III DUAL USE APPLICATIONS: MILITARY: These integrated elements will allow for the future integration of optical elements, and driving electronics into a single unit. This will result in small, high-performance
intelligent devices suitable for applications including: free-space adaptive laser communication, real-time target tracking and designation, aberration-free imaging, and laser weapons systems. NON-MILITARY: free-space communication, laser technology, medicine.

REFERENCES:

KEYWORDS: free-space laser communication, communication systems, integrated phase shifter, phase control devices, phase locking

A04-036 TITLE: Radar Target Signature Modulator

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: FCS

OBJECTIVE: Research and develop a Radar Target Signature Modulator (RTSM) capable of converting a radar point target return signal into a complex target return signal typical of a moving target with dynamic attributes of target body length, aspect angle variation and other features of realistic target signatures. The resulting RTSM would work with existing standalone far-field radar target simulators to provide higher fidelity target return signatures required to exercise a wider range of target discrimination capabilities being incorporated in modern radar systems.

DESCRIPTION: Current standalone far-field radar target simulators used to exercise ground-based air defense radar systems in the field typically generate radially dynamic point targets by receiving the radar waveform, processing it and transmitting it back to the radar under test. The processing performed by the target simulator includes delaying the received radar signal by a programmable time interval corresponding to the simulated target range, translating the signal by the desired Doppler offset frequency, and scaling the signal amplitude in accordance with the desired target cross section. While this target simulator processing has proved adequate for exercising radars with limited target discrimination capabilities, the advent of increasingly sophisticated target discrimination techniques in modern radars presents new challenges for standalone target simulators.

The RTSM envisioned in this effort would take a radar point target return signal generated by a standalone radar target simulator and operate on it by generating multiple parallel modulated signal streams corresponding to multiple scatterers from a complex dynamic target and then combine these streams in a way that produces a composite output waveform resembling a realistic target return. The proposed effort includes research to determine the number and configuration of scatterers needed to represent the dominant features of four target types: fixed wing fighter jet aircraft, rotary wing aircraft, unmanned aerial vehicle (UAV) and theater ballistic missile (TBM). Based on the findings of this research, the offeror shall develop a proposed RTSM design with the capability to generate an output signal with the number of scatterer components required to represent the dominant features in each of these target types. Each scatterer should have independent dynamically programmable amplitude, phase, and polarization characteristics relative to an unpolarized input signal to allow the user to configure the RTSM for various targets. Extra consideration will be given to designs that focus on target signature features most likely to be used as discriminants for target classification in modern air defense radars. The RTSM must be capable of handling input radar waveforms of arbitrary complexity including both pulsed and Continuous Wave (CW) waveforms. Extra consideration will be given to designs that either incorporate or are extensible to a multiple number of target channels ranging from four to sixteen. The RTSM should be a mobile rackmount system capable of operating in a field van in conjunction with a radar target simulator system. The RTSM will be required to operate over a temperature range of +0C to +50C inside the van, utilizing 115VAC 60Hz prime power and occupying no more
than half of an instrumentation rack. The RTSM should be remotely controlled over a digital interface by a userextensible program running on a government personal computer (PC) controller. The design of the proposed digital control interface and the RTSM command/query syntax should allow the user to configure and operate all functions of the RTSM under program control from a remote PC. The RTSM development effort should include a representative target model with corresponding RTSM configuration/setup instructions for each of the four target types mentioned above.

Realizing that this effort to develop the RTSM involves a significant amount of technical risk, many of the objectives set forth in this topic are design goals rather than hard requirements. Extra consideration will be given to proposals that meet or exceed these goals. The desired instantaneous operating frequency range of the RTSM is 9.0 to 11.0 GHz. This may be reduced to the range of 9.0 to 10.0 GHz, however further reductions will be judged nonresponsive. All input and output signal ports in the RTSM should be 50 ohm impedance with Voltage Standing Wave Ratios (VSWRs) of less than 2:1 and utilize APC 3.5 female connectors. The RTSM maximum input signal level should be +23 dBm or less. RTSM output signal levels should not exceed +23dBm and should exhibit a power level variation of less than +/- 1 dB for a given frequency agile input signal across the operating frequency range.

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

PHASE II: Procure or develop the system components specified in Phase I. Fabricate the RTSM system prototype proposed in Phase I. Characterize and refine the system performance in accordance with the goals stated in the description above using the four representative target models developed in the effort. Compare the system performance for the representative target models with published measured data where possible. Document the system theory of operation, design, component specifications, system performance and any recommendations for future enhancements.

PHASE III DUAL USE APPLICATIONS: The proposed R&D effort has commercial application to microwave signal processing functions in radar and communications systems utilized in both commercial and military sectors. The proposed modulator development would provide a means of generating dynamic complex signal scattering effects typically encountered by a radar or communication system. This would leverage the capabilities of radar target simulators and communication system link simulators to include complex dynamic scattering effects typically observed in real-world environments. Enhanced radar target simulators incorporating this technology would enable improved testing and training activities on newer radars with target discrimination and classification capabilities. This would be useful to both air defense and air traffic control activities. Communication link simulators incorporating this technology would be better equipped to investigate the effects of intentional and unintentional scattering effects such as those encountered by mobile GPS and communication systems in urban and other settings.

REFERENCES:

KEYWORDS: radar, target, cross section, RCS, glint, scattering, scintillation, simulation, modulator

A04-037 TITLE: New Concepts and Tools for Unit Design and Evaluation

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: FCS

OBJECTIVE: The purpose of this research is to increase productivity and efficiency of Army organizations through improved models of organizational dynamics, structure, and function.

There is no doubt that improved models of organization structure, regarding assignment of tasks to personnel, will enhance productivity and reduce manpower needs. However, given emerging information systems, and the demands of asymmetric warfare, we must go beyond task assignments and consider the organization structure as a whole. As an example, as sensors provide more information in a dynamic context, how should decision making processes and levels of authority be modified to gain advantage of the enhanced information systems? If a more decentralized structure is needed to enable rapid decision making, what other factors need to be adjusted to coincide with the more decentralized structure? This project would identify critical factors of organization dynamics, structure, and function, in order to develop a tool that predicts the optimal mix of factors given mission goals, requirements, resources, and capabilities. This topic is related to enhancement of information systems and enhancement of human systems.

DESCRIPTION: Recent Army acquisitions, such as Stryker and the Future Combat Systems (FCS), underline the importance of coordinated action and supporting organizational structure. Army Lessons Learned observe, for example, that new equipment, new doctrine, and new tactics, techniques, and procedures create the need for new
organizational structures, such as that proposed for the FCS-equipped Unit of Action (UA). We need to be able to specify the kind of infrastructure that will really harness these new capabilities.

Recent research indicates that organizational effectiveness is affected by structure (e.g., centralized, decentralized, matrix, networked, etc.), resources (e.g., equipment, capabilities, information, etc.), and function (e.g., mission, tasks, roles, responsibilities). It also depends on factors related to organization dynamics (e.g., span of control, decisionmaking authority, stakeholder influence, informal authority structure, cohesiveness, cooperation, trust, etc.). We need principles and tools that can quickly specify an optimal mix of these factors, given the mission.

In fact, there is now a very rich array of studies yielding data and recommendations. Quantitative models have also been developed for organization-level factors such as member commitment, organizational learning, organizational memory, degree of trust, decision making processes, communication structure, organizational complexity, information flow, knowledge overlap, and workload. Aspects of these models have been validated in experimental sessions. Given these findings, how can we identify the critical factors most likely to enhance operations, given mission goals, requirements, resources, and capabilities? Given this foundation of scientific work, we need to identify broad principles that will quickly indicate critical factors and their effect on organizational performance and effectiveness, given mission goals, requirements, resources and capabilities.

This effort would be accomplished through: (a) specifying the factors most likely to affect organizational effectiveness, (b) specify the principles that would identify an optimal mix of these factors, given a particular organizational context and structure, and (c) developing methods and supporting tools that can quickly and easily provide these recommendations to users.

PHASE I: Specification of factors, principles, and a proof of concept. This will include a literature review to identify factors and principles most likely to affect performance and effectiveness, given an operational setting that includes emerging capabilities in information gathering, distribution, and display. It will focus on the question: Given an information-rich context with network-centric goals, how do we structure the organizational and decision making processes to enhance organizational productivity and effectiveness? An example of enhanced performance given mission goals would be more rapid and effective decision making and coordination of events. What other factors are critical and complementary? Once the factors and principles have been specified, a proof-of-concept automated tool will be developed that will demonstrate the approach by which --given a particular mission, its goals, requirements, resources, and capabilities—recommendations can be generated regarding organization structure. In addition, a technical report will document the review of literature, guiding principles, and the method and mechanisms that would drive a phase 2 deliverable.

PHASE II: Development, refinement, and validation of automated tool. Develop a fully specified and functional prototype unit evaluation model based on the full array of factors identified in Phase I. Conduct experimental research to support or augment selected critical principles generated by the tool, given emerging mission goals, requirements, resources, and capabilities. This would be done through an experiment that will compare performance and processes in organizational structure manipulations that include the tool-based recommendations for innovation, to the structure that is currently operational. Deliver the technical report and software that enables ease of use of the tool.

PHASE III: Significant public and private sector commercialization opportunities exist today for a modeling tool of this kind. These opportunities are likely to grow as increasing applications of information technology require organizations to restructure in order to realize anticipated productivity gains.

REFERENCES:


A04-038 TITLE: Soldier Universal Robot Controller

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design and build an innovative universal robot controller that allows a dismounted soldier to control and task various small robotic platforms. The interface shall be capable of controlling small robots and their functions without causing unnecessary additional weight, and without the addition of bulky add-ons to the Land
Warrior Infantry Soldier System (PEO Soldier Warrior). We envision an interface that can use a mechanical input, speech, gesture, tactile gloves, Personal Digital Assistant (PDA), or gaze to control and task robots (ground/air) of varying capabilities (completely tele-operated robots to an autonomous robot from a soldier-worn system).

DESCRIPTION: Physical agents, such as robotic platforms, will be ubiquitous on the battlefield of the Army’s Objective Force, significantly lowering the risks to our soldiers and increasing the soldiers’ situational awareness. These robots must be able to not only collaborate amongst themselves but also with their manned partners. Their roles will range from scout missions, to urban warfare or urban rescue, to mules (carrying the soldier's equipment). The human/robot interaction with these agents must be highly efficient and minimally intrusive. The interaction with the robots must not encumber the soldiers. Additionally, communications between the robot and soldier must be minimized to reduce bandwidth. Therefore, a universal robot controller is necessary to control all of the functions of the robot without overburdening the soldier with extra equipment or extra tasks.

A universal robot controller is required to control various types of robots, which may be sent out ahead of the soldier as a scout or pointman, or may be programmed to follow behind and carry the soldier's equipment. The control of the robot may be tele-operated, programmed using waypoint designation on a map, or may be more autonomous. The universal robot controller must allow the soldier to task the robot in any manner and perform any of its functions without additional bulky equipment, and without taking his full attention off of other mission tasks.

The universal robot controller must not only provide for input to the robot from the soldier, but must also convey the information to the soldier via his heads-up display, his computer tablet, or by some other means. The universal robot controller shall be Joint Architecture for Unmanned Ground Systems (JAUS) compliant.

It is anticipated that this universal robot controller and a small robotic platform will be utilized with existing Land Warrior or prototype Objective Force Warrior (OFW) systems for experimentation, therefore compatibility and integration with future Land Warrior Systems, OFW Systems and their components are desired.

This program assumes that the Soldier Universal Robot Controller will be interacting with one or more robots supporting the dismounted soldiers with varying capabilities from teleoperation to autonomous. Proposed robots for use in this program include the iRobot Packbot and potentially the GDRS XUV robot. iRobot is currently the Future Combat Systems (FCS) contractor for the FCS Small Unmanned Ground Vehicle (SUGV).

Prospective candidates should address the following universal robot controller design features: 1) proposed input hardware and modalities, 2) proposed display integration, 3) proposed integration into existing Land Warrior hardware and software, and 4) software, mechanical, and electrical design characteristics such as physical size, power consumption, mission duration, and interface with a small robotic platform.

PHASE I: Conduct preliminary research and design a universal robot controller to control and task various small robotic platforms. For the proposer’s concept to be successful, the controller must display information from the robot and be capable of interacting with the host small robotic platform. Additionally, the design should consider interaction with the FCS and OFW architectures, and how the proposed design could affect the FCS or OFW architectures.

PHASE II: Using the concepts and design developed in Phase I, produce a fully functional prototype universal robot controller that is operational with a Land Warrior system and a small robotic platform. A highly successful Phase II would include a proof of principle demonstration. This demonstration should include preliminary tests using multiple small robotic platforms with Land Warrior equipped soldiers in which the functionality/utility of the universal robot controller can be established.

PHASE III: Urban search and rescue is the most natural dual-use application for this technology. A robust and reliable universal robot controller could be used by fire and rescue personnel, police, and other agents to control small robotic platforms in collapsed building environments, sniper situations, fires, bomb disposal and interaction and chemical contamination environments.

REFERENCES:
KEYWORDS: robotics, universal robot controller, Objective Force Warrior, Land Warrior, FCS

A04-039  TITLE: RF Unattended Ground Sensors (UGS) for Retargeting

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PEO Soldier Warrior

OBJECTIVE: Design, build, and test a set of RF sensors capable of networking with one another and with other similar sensors to detect, locate, and classify moving targets. The sensor should be designed in such a manner as to minimize cost, volume, and weight; and to maximize ruggedness and operational time.

DESCRIPTION: The Army Research Laboratory (ARL) has been investigating the potential of a distributed network of RF UGS for providing dynamic retargeting of extended-range munitions. Radar sensors operating in a Moving Target Indicator (MTI) mode have the capability to provide accurate estimates of range and Doppler velocity. The RF sensors must have the capability to remain dormant for an extended period of time, and to become operational when cued by another sensor. The main challenge is to design a sensor with low cost to enable the deployment of a large number of disposable sensors in a network. The sensor must have a combination of low power consumption and good power storing capacity in order to prolong its operational lifetime; the sensor must be contained in as low a volume as possible in order to minimize the chance of discovery, and it must possess low weight to facilitate its deployment.

PHASE I: Research, conceptualize and design an RF sensor for implementation of a Distributed Sensor Network (DSN), and provide its fundamental specifications and capabilities and its expected performances. Research and understand the operations of the DSN and provide a conceptual protocol of the network operations. The sensor should demonstrate incremental progress toward achieving the following government performance goals: a sensor range of 50-200 meters, a range resolution of 20-40 meters, and velocity resolution of 1.5-3.0 meters per second. The sensor should cover 360 degrees in azimuth with a vertical coverage from 0 to 30 degrees. The antenna should not extend more than 0.8 meters off the ground during operation. The radar should operate as a multifunction RF (MFRF) device in the 1.215-1.3 GHz band in order to offer good propagation characteristics in dense vegetation areas, establish and maintain communication, and capture the Global Positioning System (GPS) signal. The government has priority in the use of the band between 1215 and 1300 MHz. As activity in this band may conflict with other devices, especially those making use of GPS, care must be taken to use techniques that minimize (this) possibility. The sensor must have enough computing capability to control the operations of the receiver/exciter, handle the communication with the network controlling entity, and reduce the radar returns to a list of range and Doppler speeds of all the detects. The network must be able to self-organize and to determine the position of its constituent sensors with a minimum number of sensors equipped with a GPS receiver.

PHASE II: Building on the results of the Phase I sensor design, a successful Phase II project would lead to the further design and development of five prototype sensors for evaluation. Accomplishment of as many Government goals as possible from the Phase I above is desirable.

PHASE III: The main function fulfilled by a network of UGS is the autonomous monitoring of an area for any presence of objects in motion. This capability, carried out over a relatively long period of time without the need for human supervision, make such networks ideal for, among others functions:
a. Monitoring of wildlife activity in conservation areas.
b. Providing site security for warehouses, airports, businesses, and fulfilling many Homeland Security demands etc.
c. Monitoring vehicular traffic.

REFERENCES:

KEYWORDS: Unattended Ground sensors, Distributed Sensor Network, Radar Frequency, Moving Target Indicator, Doppler, Global Positioning Satellite, disposable sensors

A04-040 TITLE: Innovative Gas Path Sealing Concepts for Improved Turbine Engine Performance

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Soldier Warrior

OBJECTIVE: Develop innovative gas path sealing concepts for improved turbine engine performance in both military and commercial engine applications.

DESCRIPTION: The U.S. Army seeks innovative gas path sealing concepts that improve turbine engine performance at increased operating engine speeds, pressures, and temperatures on air/ground platforms that support missions such as reconnaissance, deployment, and combat. Current 2003 Integrated High Performance Turbine Engine Technology (IHPTET) Phase III goals for turboshaft/turboprop engines include a reductions in specific fuel consumption (SFC) of 40%, while reducing production and maintenance costs by 35% and an increase in the shaft horsepower-to-weight ratio of 120%. [Ref.1] Also, the Versatile, Affordable, Advanced Turbine Engines (VAATE) program metrics are for a 3x to 5x improvement in the capability/cost index for turboshaft/turboprop engines. [Ref.2] The emphasis of this solicitation topic is on high risk, breakthrough, revolutionary turbine engine gas path sealing technologies. Studies have shown that advanced seals improve engine efficiency while decreasing acquisition costs, operating costs (i.e. fuel consumption), and overall engine maintenance. [Ref.3]

Improved engine performance enhances air/ground platform mobility at the tactical, operational, and strategic levels. Probability of air/ground platform survival increases due to improved engine performance. Durable, advanced seal technology improves the engine time on the air/ground platform extending maintenance intervals, improving readiness and allowing the vehicle to stay in operation for longer periods of time in the battlefield. Finally, improved SFC reduces fuel cost and/or enhances mission length or allowable cargo weight. These advanced seal characteristics improve all the Army FOCs mentioned above.

PHASE I: Demonstrate or determine the scientific, technical, and commercial merit and feasibility of the proposed innovative seal concept(s). The proposer shall demonstrate analytically, or, preferably, via experiments the feasibility of the approach to meet IHPTET and VAATE program goals as described above. The proposer shall submit a comprehensive plan for follow-on work to be performed under a Phase II program. The proposer shall also submit plans for commercializing his/her concept(s) under a Phase III program.

PHASE II: Design, build and test an innovative engine seal concept and conclusively quantify results towards IHPTET and VAATE program goals. The minimum Phase II demonstrated sealing performance requirements are:
1. Non-contacting operation
2. 75F air temperature (material capable to 1200F)

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3. 1200 feet per second
4. 100 pounds per square inch
5. flow factor less than 0.006 [Ref.4]

PHASE III DUAL USE APPLICATIONS
Military Application
Black Hawk UH-60 utility helicopter
Apache AH-64 attack helicopter
Chinook CH-47 cargo helicopter
Kiowa Warrior OH-58 observation/scout helicopter
Comanche RAH-66 reconnaissance/attack helicopter
M1 Abrams main battle tank
Army Future Combat System vehicles
Unmanned air and ground vehicles

Commercial Application
Commercial engines and auxiliary power units on passenger jetliners, helicopters, business aircraft and stationary turbine electrical power generators

REFERENCES:
1) http://www.vtol.org/IHPTET.HTM
2) http://www.pr.afrl.af.mil/divisions/pr/VAATE/vaate.htm
3) http://www.lerc.nasa.gov/WWW/TurbineSeal/E11109.pdf

KEYWORDS: seals, turbine engine, IHPTET, VAATE

A04-041 TITLE: Multipurpose Reactive Materials

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Soldier Warrior

OBJECTIVE: A new generation of intriguing materials have been studied for the past few years that represent a major technology breakthrough with important implications for the Army. These non-explosive materials, broadly referred to as “Reactive Materials” (RM) are discontinuous composites. The baseline material has centered around low density aluminum/Teflon (Al/PTFE). These materials, relative to classical explosive energetic materials, do not detonate and can actually be used as a structural material (they are considered a flammable solid). Warhead cases fabricated from RMs throw fragments which can ignite upon target impact and release enormous energy and cause catastrophic damage (unlike conventional metal war head fragments that only penetrate the target). It is desirable to develop the next generation RMs which will provide lethality enhancements for many applications. These include: multipurpose reactive fragments for application against UAV’s and other aircraft, and advanced thermobaric warheads (with enhanced blast/impulse) for shoulder-fired weapons, deep penetrators and advanced shaped charges against hard targets with behind armor effects. In addition, it is also important to enhance the lethal radius of explosive warheads with thermobaric fuels as well as provide an RF component to the fireball so that a multifunction warhead can disable electrics, and installations beyond the high-pressure regions.

DESCRIPTION: It is also important that this program will develop new RMs with a range beneficial properties in order to address defeat of Chem/Bio targets in storage or in flight with the appropriate fireball properties including temperature, chemical activity and controlled peak pressure especially for targets in storage (high temperature to burn the agent, not detonate and spread the agent). The main objective of this SBIR is to advance the reactive materials technology in terms of new formulations and the processes to produce them and demonstrate their lethality effectiveness in multipurpose Army warheads. Emphasis should be placed in reactive materials, reactive composites alone and in combination with conventional explosives so that multifunctional performance is possible and
transition into a hardware development program is feasible. Specific items of interest and desirable properties of multipurpose RMs include high reaction temperatures (~4,000K) large amounts of chemical energy (2-3) Kcal/g controlled reactivity by shock with a wide range of warhead applications in terms of blast impulse, behind armor effects, chem/agent defeat, as well as RF.

PHASE I: Analyze all promising NEW reactive material combinations with thermochemical code calculations and evaluate or rank in terms of their potential for warhead enhancement in the areas of Army interest as described above. Characterize the most promising candidates by key laboratory experiments in terms of significant properties which will govern the potential utility of each composition. Select those combinations, which play the widest multifunctional role.

PHASE II: Design, fabricate and test prototype-scale warhead devices or components such as reactive fragments, reactive fills, reactive liners and compositions addressing Chem/Bio defeat and RF generating fireballs. Evaluation tests will be conducted at the contractors’ facility as well as at an Army Research facility for direct comparison with baseline warhead materials and devices.

PHASE III: The developed technology will be inserted/transitioned into several Army hardware programs for weapon development efforts. Private sector commercial potential: The proposed technology will have many commercial applications including oil exploration, commercial blasting, high temperature synthesis of new materials, etc.

REFERENCES:

KEYWORDS: Reactive Materials, weapons, warheads, thermobarics, chemical agent defeat, biological agent defeat

A04-042 TITLE: Blast Damage Analysis

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM-MAS

OBJECTIVE: To develop a method/tool to characterize vehicle failure and/or residual vehicle capability as it relates to given structural damage that is caused by a blast environment. This new tool shall be capable of analyzing both existing and future vehicle technologies to the effects of blast damage produced by a conventional weapon.

DESCRIPTION: Future Army systems are becoming more lightweight and thus are becoming more susceptible to the blast and shock effects of conventional weapons. The thinner walled vehicles of advanced materials allow a greater transmission of energy to the internal components and are also more vulnerable to rupture due to the blast environment.

The Army has been utilizing computer aided design (CAD) modeling tools with complex survivability analysis tools, like MUVES S-2 (Modular Unixed-Based Vulnerability Estimation Suite) to determine the survivability of ground vehicles to conventional weapons effects for many years. The blast effects from these weapons have largely been ignored because the ground targets have been so robust. The Future Combat Systems (FCS) will be a lighter weight system of systems and blast effects will have a greater impact then ever before. Techniques are currently being developed to determine the blast damage that occurs to a vehicle's structure. This damage will be in the form of permanent deformations, panel delamination, or complete panel failure. A stand alone module that can determine the vehicle damage effects and/or residual capabilities of the vehicle due to the blast damage is needed to complete the overall MUVES-S2 modeling suite.
PHASE I: (1) The contractor shall design and develop the methodology/tool to determine the vehicle damage and/or residual vehicle capabilities as it relates to structural damage induced by a conventional blast environment. The proposed methodology shall consider advanced lightweight materials.
(2) The contractor shall demonstrate a preliminary version of this new method through the use of test cases and demonstrate how it can be linked to other computer codes like the MUVES S-2 computer code. Detailed knowledge of the MUVES S-2 code is not required in this Phase of the effort and this linkage should only be considered as a minor part of the overall effort.

PHASE II: The contractor shall extend the Phase I methodology to the full capability of a productive tool for blast analysis. The tool shall be capable of relating structural damage (like panel failure) to the residual vehicle damage and capabilities. The new tool shall be a complete software package that meets the requirements set forth in Phase I, and shall interface with the MUVES S2 Computer code. Detailed knowledge of the MUVES S-2 code is not required, and all input requirements will be provided.

PHASE III DUAL USE APPLICATION: The creation of this tool will have a broad range of commercial applications. Not only will it directly impact to blast/shock modeling capabilities, it will also be applicable to civilian defense issues.

OPERATING AND SUPPORT COST REDUCTION (OSCR): Development of such a tool will greatly enhance the overall survivability analysis process. This increased capability will have great impacts upon the operation of equipment on the battlefield, and its survivability levels.

REFERENCES:

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

A04-043 TITLE: Manpower and Personnel Estimation Methods for Post-Deployment Software Maintenance

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PM-MAS

OBJECTIVE: The objective of this research is to develop methods and tools to facilitate the definition of post-deployment software support staff selection, staffing level, and training requirements for emerging weapon systems. In formulating these requirements, the resulting methods and tools should help planners determine the sensitivity of such requirements to changes in maintenance doctrine, changes in the external environment (e.g., changes in user requirements, hardware change), changes in maintenance-related process design, and variations in human performance to determine their effects on both maintenance and operational unit performance (e.g., go-to-war capability, availability).

DESCRIPTION: Previously taken for granted, software is now recognized as the highest risk system component in virtually every major defense acquisition. The ultimate success or failure of the doctrine of information dominance depends, to a large extent, on the a well-designed and executed software sustainment capability. The magnitude of this problem is evidenced, in part, by the growth of software as a part of the overall weapon systems acquisition enterprise. When the C-17 development program began in 1985, the Government planned the development of 4 subsystems with about 164,000 lines-of-code. By 1990, this number had increased to 56 subsystems and about 1,356,000 lines-of-code, including approximately 643,000 newly developed lines-of-code.
Software modifications for F-16 avionics, mission planning, or automatic test equipment for all U.S. and foreign military sales aircraft is approximately one million lines-of-code per year. The Army’s Future Combat System (FCS) will be a networked system in which every piece of equipment on the battlefield, from tank to drone, is connected by about 33 million lines of software code. Today, software maintenance costs account for somewhere between 50% and 80% of the overall software life cycle costs. In the face of such trends, the magnitude and importance of a well-designed software sustainment strategy is critical to future force operations. Yet, decision-makers today have very limited analysis and decision support capability to identify and make effective tradeoff decisions.

PHASE I: Conduct research to identify key factors affecting post-deployment software support needs. Develop a preliminary methodology for defining the necessary support processes, required skills and staffing levels, training needs, metrics, and anticipated service levels for a notional or real post-deployment software support scenario.

PHASE II: Conduct additional research to expand post-deployment software support scenario(s) developed under phase I effort. Develop requirements and preliminary design for the tools needed to support the methodology. Develop pre-production prototype system for post-deployment software support needs analysis. Apply the developed methods and tools to a real-world context.

PHASE III: Significant public and private sector commercialization opportunities exist today for technologies of this kind and will likely grow as software becomes an increasingly integral part of military and commercial systems and products. The envisioned technology will enable software supportability analysis early in the system design process together with the other “-ilities” involved in multidisciplinary design. Military and civilian applications include sustainment planning, life cycle cost estimation, manpower planning, and training requirements definition.

REFERENCES:

KEYWORDS: Software, Maintenance, Logistics, Modeling, Simulation

A04-044 TITLE: Flexible Transparent Conducting Films
TECHNOLOGY AREAS: Materials/Processes
ACQUISITION PROGRAM: PM-MAS
OBJECTIVE: Design and synthesis of a family of flexible, optically transparent conducting films.

DESCRIPTION: The objective of this solicitation is to develop a family of novel flexible optically transparent conducting films. The research will build upon organic and inorganic based conductor technologies. Organic (polymer) low bandgap semiconductors should be used as a component because of their desirable physical characteristics, they tend to be flexible. Unfortunately, organic semiconductors are highly colored and not pure conductors, by definition. Inorganic conductors should be used because of the ability to selectively control the resistance and optical properties of these materials. Inorganic conductors, alone are brittle and incapable of forming flexible systems. Therefore, this research will focus on the development of organic and inorganic materials as well as inorganic/organic hybrid conducting films. The synthesized films will be optically transparent and flexible. The films will demonstrate no fluctuation in resistance during or after flexure.
Neither pure inorganic nor pure organic semiconductors may be adequate solutions to the stated objective of this solicitation. However, a film composed of a combination of inorganic conductors and organic semiconductors may be a logical solution. Proposals will be sought for material solutions based on organic or inorganic materials as well as hybrid organic/inorganic materials. The Army and other technological based entities would benefit from the development of flexible optically transparent conductive films which would be applicable for use in flexible displays, robust EMI shields and robust circuitry components for navigational systems, weapons systems, engine components, etc. Fiber forms of the films could be used for displays and as transparent wiring.

The US Army has a Flexible Display Initiative that is establishing a university-led Center to integrate the critical flexible display technologies with industrial and academic partners. All flexible display technologies have as one of the critical elements an electro-optic imaging devices that requires a transparent conductor. This represents one such application for the technology described in this SBIR solicitation.

PHASE I: The contactor shall, based on a previously completed survey of literature, design and synthesize novel inorganic/organic hybrid flexible optically transparent conducting films. Resistance, optical, and mechanical data will be reported for the candidate films. A 4-inch by 4-inch specimen of each candidate film will be delivered to the U.S. Army research Laboratory POC for further evaluation.

PHASE II: Based on the knowledge base gained in PHASE I, the contractor shall improve upon the synthesis of the selected candidate films and down select based on MIL-STD-810E. The contractor shall investigate and propose the beneficial placement of these films in existing and future Army hardware systems. Of particular interest, are applications of the developed films in flexible displays and in adaptable electronic devices.

PHASE III: The successful development of flexible optically transparent conducting materials will have applications in nearly any industry. Optically transparent flexible conductors are critical to the commercial and military success of flexible displays, particularly for top emitting and reflecting active matrix displays. The PHASE III effort will include flexible transparent conductive films on standard flexible substrates as well as commercial materials for transparent, flexible conductors to be deposited onto electronic devices.

REFERENCES:
1) See, for example, commercial products that require flexible, transparent conductive coatings, and specifications required for such products available from http://www.bsf.com.

KEYWORDS: ITO, optically transparent film, inorganic/organic hybrid, conducting film, flexible, adaptable
Research and Development Goals: The proposed digital receiver should be capable of measuring intended and unintended spectral emissions of electronic equipment in a very dense, noisy signal environment. These emissions, particularly the unintended emissions, are typically very low in amplitude and can number in the hundreds. The receiver architecture should employ direct digital sampling and Fast Fourier Transform techniques to achieve near real time processing of massive data sets. The receiver architecture should utilize a modular, expandable design approach allowing receiver subsystems to be upgraded as advances in signal conversion and massively parallel digital signal processing become available. A key design goal for the proposed receiver is the ability to capture and process power spectral density data over an instantaneous signal band of 10 MHz to 1 GHz. The proposed receiver should be capable of resolving signals with frequencies differing by 0.1 Hz as a design goal. Receiver designs incapable of resolving signals closer than 75 Hz in frequency will be considered non-responsive to topic requirements. Another key design goal for the proposed receiver is a spurious-free dynamic range of 70 dB or more. Extra consideration will be given to receiver designs with higher spurious-free dynamic ranges. Designs with a spurious-free dynamic range of less than 45 dB will be considered non-responsive to topic requirements. The receiver should output a digital record of scaled Power Spectral Density (PSD) of the input signal referenced to 1 mW (0 dBm). The RF input should accept bipolar input signals into a 50 ohm SMA connector with programmable input ranges of +/- 10mV, +/- 20.0mV, +/- 50mV, +/-100mV, +/-200mV, +/- 500mV and +/- 1000mV. Extra consideration will be given to designs incorporating innovative techniques for rapid analysis and transmission of received data to Personal Computers or Workstations for further post processing. The proposed receiver should be man portable and mountable in a standard 19 inch rack with a weight less than 80 lbs. The receiver should operate over an ambient temperature range of 0 to +50 C. Prime power available to the receiver is standard 115VAC, 60Hz.

PHASE I: Conceptualize and design the proposed receiver system with the potential of realizing the goals in the description above. Develop technical specifications for all system components and identify them as commercially available or to be developed. Model and predict the performance of the proposed system, identifying critical components to be developed. Conduct detailed theoretical and/or laboratory investigations on the design and performance of critical components to demonstrate the feasibility and practicality of the proposed system design, including mitigation of risks associated with factors limiting system performance. Deliver a report documenting the research and development effort along with a description of the proposed system and specifications for system components.

PHASE II: Building on the results of Phase I design, fabricate the system proposed in Phase I. Characterize and refine the system performance with the intent of making considerable progress to the accomplishment of the goals stated in the description above. A highly successful Phase II would deliver a prototype system along with a report documenting the system theory, design, component specifications, performance characterization and recommendations for system performance.

PHASE III DUAL USE APPLICATIONS: The proposed research and development effort has wide commercial application to digital signal processing functions in military and commercial applications. This R&D effort will yield advancements in the ability to digitally process data on smaller, more efficient machines. Military applications include digital signal processing engines useful to radar receivers, SONAR, surveillance systems, communication systems and image processing. Commercial applications include the commercial counterparts of the military systems and medical imaging. A digital signal processor engine capable of operating on extremely large data sets might also find application in the area of applied mathematics, astronomy and the geosciences.

REFERENCES:

KEYWORDS: Digital receiver, broadband spectral measurement, digital signal processing, high speed A/D conversion, surveillance receiver
TITLE: Development of Long Ceramic Tubes for Gun Barrel Applications

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Henry Girolamo, Natick Soldier Systems OFW Displays POC

OBJECTIVE: Solve the Army’s need for long (2 meters or longer) monolithic Si3N4-based ceramic tubes for use as a liner in gun barrel systems.

DESCRIPTION: The metal gun barrels currently used by the Army for a variety of systems have a short lifecycle and cannot handle many of the higher energy propellants being developed. It is anticipated that ceramic gun barrel liners will: 1) provide a 50% increase in barrel life with sustained accuracy for direct and indirect fire; 2) enable a 20% increase in muzzle kinetic energy for direct fire, and 3) provide a 5-25% weight reduction (per unit length of barrel) owing to the combination of superior wear resistance, high temperature capability, and relatively low density that are inherent to ceramic materials. The development of a ceramic gun barrel will reduced maintenance costs while serving as an enabling technology for the use of higher energy propellants. An optimized ceramic gun barrel design should be capable of producing significantly higher lethality than current direct fire weapons. Initial investigations of ceramics for gun barrel applications indicate that this potential can be realized. However, current ceramic manufacturing technologies limit the length of a tube that can be produced with the dimensional tolerances (outer and inner diameter tolerances of ± 0.15mm) required for gun barrel applications. Ceramic tubes with a variety of inner and outer diameter combinations can readily be made in lengths up to 200mm but at longer lengths minimizing bowing and maintaining dimensional integrity become issues.

PHASE I: Study and demonstrate the feasibility of a procedure to produce a long, near-net shape monolithic ceramic tube for use as a ceramic gun barrel liner. The Army’s early results indicate the best performance can be achieved with ceramic made from the silicon nitride family of materials with a density of > 98% of theoretical. Although, alternate proposed materials could be considered. The desired process must be able to produce liners meeting the following typical requirements: The tube must have a 33mm outer diameter (OD) and a 24 mm inner diameter (ID) with a tolerance of +/- 0.15mm for both dimensions. The proposer would be expected to report and if successful demonstrate a process for making a 500mm long tube without bowing and with dimensional integrity over the entire length of the tube.

PHASE II: Building on the successful results of Phase I, improve the procedure for manufacturing near-net shape ceramic tubes for use in a medium caliber gun system. A goal of this program is the ability of the process to create tubes with the same OD and ID combination from Phase I but with longer lengths. Ideally the first year of the Phase II effort will focus on the fabrication of tube lengths up to 1 meter and progress towards 2 meter long tubes during the second year. Qualify and quantify the performance of the tube by generating mechanical and thermal property data using standardized procedures applicable to current gun barrel systems. Perform a cost analysis assessment for future production. Reasonable performance related goals expected to be achieved by the proposer related to the execution of this project are the demonstration of the selected ceramic tube production process through the generation and delivery of three prototype ceramic tubes, each 1m long. These tubes will be delivered to the US Army Research Laboratory (ARL) for evaluation. Similarly, a successful second year of this Phase II effort could be expected to demonstrate and deliver three additional prototype ceramic tubes, each 2m long, to ARL, for evaluation.

PHASE III: Ultimately, the procedures developed, during the performance of this SBIR for manufacturing long length ceramic tubes will then be scaled and applied to other caliber gun systems such as the 5.56mm, 7.62mm, 50 cal, 120mm, and 155mm. This development could change the state-of-the-art for the military gun barrel technology as we know it, with tremendous savings realized by the Army because of increased accuracy/lethality and longer lifecycle.

DUAL USE APPLICATIONS: The successful development of a rifled ceramic gun barrel would have wide reaching applications to other caliber gun systems. Law enforcement, homeland defense and other security agencies could greatly benefit and save lives through the application of the potential of this technology.
REFERENCES:

KEYWORDS: Ceramic tubes, Ceramic Processing, Gun Barrel Liners, Silicon Nitride Ceramics

TITLE: Graphical/Visual Multiscale Model Builder & Data Structure

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: Henry Girolamo, Natick Soldier Systems OFW Displays POC

OBJECTIVE: Develop a robust multiplatform visualization suite and data structure for depicting multiscale data sets to enable advanced modeling capability of state-of-the-art physics solvers and realistic problem sets. Particular emphasis should be on enabling accurate data structures that combine atomic datapoints with structured or unstructured numerical grids and meshes for general 2D and 3D applications.

DESCRIPTION: A severe limitation in research and development of modeling methods for nanotechnology is no longer in the theory alone, but in the interface between user and software. Modeling of complex crystal lattices, unstructured finite element grids, and the necessary features possessed by both to make their juxtaposition an interesting problem often takes substantially more time than the solutions of the problems themselves [1-3]. It is not uncommon to require hundreds of man hours developing even the simplest test problems, limiting both production-level simulation cycles as well as basic code development. The software tools in the respective areas of crystal/molecule building and unstructured mesh generation are available and independently robust for both 2D and 3D applications. However, it is still unclear what information needs to be preserved/extracted from these technologies and how they are to be modeled together at the interface. Adding to the complications are different considerations in the underlying theory that may have a direct affect on the model building process that must still be accounted for to have a truly general model builder and accompanying data structure[1,3]. For example, model variables for statics and dynamics problems may differ significantly, varying levels of modeling theory for the chemical species may require vastly different data structures, and each modeling technique for handling the atom-to-continuum transition region may use a different set of assumptions, e.g., fictitious atoms, varying cut-off radii, hybrid elements, and the like. Successful proposals will develop a interactive graphical tool that strikes a rigorous balance among computational areas involving materials science, physics & chemistry, and mechanics. Proposed tools and modeling data structures must encompass levels of theory spanning, in the least, molecular mechanics and continuum mechanics. Ideally, however, a general tool will also include modeling capability for some in the following “wish list” (among many others): all-electron methods, pseudopotentials, planewaves, real space or k-space methods, tight-binding, molecular dynamics, molecular statics, temperatures and/or thermodynamics, surfaces, crystals, crystal defects, molecular systems, finite elements, finite differences, finite volumes, boundary integrals, meshless/meshfree, continuum dynamics, and continuum statics. Each level of theory proposed for a data structure must also be accompanied by methods to visual the data for pre- and/or post-processing.

PHASE I: Survey and documentation of data structures for stove-pipe/legacy methods, identification of key variables and data types, identification of popular existing codes. Survey and documentation of data structures for multiscale-multiphysics methods, identification of key variables and data types, identification of popular existing codes.


Phase III: This final phase of the effort involves commercialization of all or parts of the final package. This should generate interest from any organization that does even modest amounts of software development.

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REFERENCES:

KEYWORDS: Graphical/Visual Multiscale Model Builder, data structure

A04-048 TITLE: InGaN Channel HEMTs for High-Frequency, High-Power Electronics

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Air and Missile Defense

OBJECTIVE: The US Army Research Lab is interested in innovative approaches to creating radio frequency (RF) devices that take advantage of the added capabilities of indium containing ternary and quaternary group III-nitride semiconductors. These devices are needed for advanced communication, radar, passive imaging, and remote sensing instruments that extend frequency and bandwidth requirements to 300 gigahertz (GHz) and beyond. Previously demonstrated impressive results of gallium nitride (GaN) based high electron mobility transistors (HEMTs) include 600 V breakdown, 3.3 mOhm-cm2 on-state resistance, high density switched current of 850 A/cm2, power densities of 6.7 W/mm at 18 GHz, 2.1 A/mm pulsed current densities and maximum oscillating frequency of 162 GHz. However, greater performance is desired as well as a repeatable manufacturing process.

DESCRIPTION: There are two major reasons to move from the ternary aluminum gallium nitride (AlGaN) to the aluminum indium gallium nitride (AlInGaN) system. First, for further improvements the aluminum molar content in AlGaN should be increased for higher band offsets and higher polarization charges leading to higher current handling capability. Doing so however, leads to uncontrolled local strain relaxation at the heterointerface via generation of misfit dislocations and cracks that ultimately show up as noise and degraded carrier transport in processed devices. However, by introducing indium, the quarternary AlInGaN gives one independent control of both lattice mismatch and band offset. Second, AlGaN HEMTs demonstrate RF large signal current collapse and RF power slump due to sluggish channel control after pinchoff. These dispersion effects are undesirable since elaborate feedback and control circuits are needed to maintain the device characteristics as what the circuit was originally designed for. The double heterostructure design of an indium gallium nitride (InGaN)-channel structure allows one to counteract channel charges with delta doping techniques.

The proposed effort should commercialize AllInGaN HEMTs with advanced designs, surface passivation techniques, field termination techniques, material growth techniques, and doping techniques. This effort must demonstrate devices that give military systems a capability much greater than AlGaInGaN HEMTs would offer.

PHASE I: Develop techniques to grow, dope and passivate excellent quality AllInGaIn/GaN/AlGaN heterostructures with the required impurity doping profiles for high performance HEMTs.

PHASE II: Optimize the AllInGaN structures and integrate them with AllInGaN monolithic microwave integrated circuits.

PHASE II DUAL USE APPLICATIONS: Development of these types of devices and AlInGaN material growth techniques are very important for a variety of dual use civilian applications such as wireless internet access, communication, pollution and biohazard detection, and medical analysis.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Military costs will be reduced by replacing current electronics with smaller lower power circuits that would run on smaller and lighter batteries and the reduction or elimination of bulky cooling systems. Also, multiple systems could be replaced with a single system that would give greater capabilities in situational awareness, communication, or electronic warfare.
REFERENCES:

KEYWORDS: AlInGaN, RF Devices

TITLE: Highly Efficient, Power-Scalable Long-Wavelength Diode Laser Pumps for Eye-Safe Solid-State Laser Development

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: Henry Girolamo, Natick Soldier Systems OFW Displays POC

OBJECTIVE: Develop novel - efficient and reliable – long-wavelength diode pumps based on innovative technology, to be used for direct resonant (into the upper laser level), ultra-low-photon-defect pumping, thus sufficiently maximizing eye-safe laser’s efficiency and mitigating thermal management problems.

DESCRIPTION: The most promising of today’s technologies for high power solid-state lasers result in wavelengths near one micron (1 um). For some tactical Army battlefield scenarios it is very important to minimize the ocular hazard zone around the laser, which favors switching to the 1.5-1.8-um “eye-safe” band. 1-um laser wavelength shifting via stimulated Raman scattering is possible, but at the sacrifice of the overall laser system efficiency and additional heat removal complications. Thus a directly pumped rare-earth doped diode-pumped laser, such as Er:YAG, is an obvious solution of choice. This laser can be pumped by conventional GaAs based 930-940-nm laser diodes, but this approach has very limited utility. One problem is the large quantum defect, the ratio of the laser photon energy to the pump photon energy, which would lead to high heat deposition in the active medium that needs to be removed in order for the laser to operate efficiently. Due to the significant dn/dT of solids, this heat deposition also causes significant beam distortions. A similar laser pumped at 15xx-nm would require a factor of ten less heat to be removed. A second problem is that 9xx-nm pumped Erbium lasers suffer from excited state absorption because an excited erbium ion tends to absorb a second 9xx-nm pump photon. Decay from the up-conversion-excited levels reduces the eye-safe laser efficiency. 15xx-nm pumped Erbium lasers do not suffer from up-conversion and could hence potentially offer higher overall efficiency in addition to smaller size and lower cost.

We are seeking offerors capable of developing efficient and reliable diode pumps based on innovative technologies, which would provide Er:YAG laser with direct resonant (into the upper laser level), ultra-low-photon-defect pumping, thus sufficiently maximizing laser efficiency and mitigating thermal management problems. We are interested in innovative ways of designing diode pumps with the wavelength in the vicinity of 1530 nm in an efficient, scalable manner.

PHASE I: Carry out feasibility study and develop an approach (materials and diode design) to achieve laser diode array output at wavelengths around 1530 nm with potential for scaling to kW’s of continuous wave (CW) power. Demonstrate the technology with a small diode bar stack emitting in the 1530 nm region and aiming at CW power ~35 W per 1-cm bar and power conversion efficiency greater than 30%.

PHASE II: Further develop the approach identified in Phase I. The Army Research Laboratory is willing to test a proof-of-principle diode bar stack with CW power ~150 W. Updating the selection of optimal output wavelength(s) in view of late developments in eyesafe solid-state laser technology, fabricate and demonstrate prototype 2D array(s) with a CW power goal of 1000 W. Deliver a report documenting the design and performance achieved, and discussing the potential for future extension to higher powers and efficiencies.
PHASE III DUAL USE APPLICATIONS: Diode arrays meeting the goals of this program would be useful not only for military applications, including tactical high energy laser weapons and lightweight eyesafe LIDARs, but also for civilian eyesafe applications such as range finders for law enforcement, obstacle avoidance for aircraft, and LIDARs.

REFERENCES:

KEYWORDS: Solid state laser, laser diode, laser diode array, eye-safe laser, high energy laser

A04-050 TITLE: Composite Proton Exchange Membranes for Multifunctional Power Generating Structures

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: Henry Girolamo, Natick Soldier Systems OFW Displays POC

OBJECTIVE: The objective is to develop a composite proton exchange membrane (PEM) for multifunctional power generating structures that is capable of generating power as part of an operational fuel cell while providing structural stiffness to the system.

DESCRIPTION: Current U.S. Army fuel cell systems consist of a PEM sandwiched between two conductive channel plates. The plates serve to provide reactants and electrical connection to the cell in addition to serving as a structural component of the fuel cell. Additional structure is required to reinforce the fuel cell systems due to the low strength of the PEM. A significant structural advantage could be obtained if the PEM were able to serve as a structural load carrying component of the fuel cell system. This multifunctionality would allow for a power generating composite structure with a reduced overall weight by eliminating the need for external stiffness and strength.

PHASE I: Propose and develop a reinforced composite PEM capable of withstanding all the various load conditions experienced by an operational fuel cell. Guidelines for appropriate systems include an operational humidity of 100%, cell temperatures of 90° C, tensile modulus of 4.0 GPa and being chemically inert to methanol. The reinforcement should provide an increase in the durability of the membrane without a significant reduction in the overall fuel cell system performance. At a minimum during Phase I, coupon testing of the candidate composite PEM samples shall be performed to fully characterize the mechanical and thermal properties. Performance of candidate composite PEM’s shall be compared to that of a standard fuel cell with an equivalent active area. Processing and design issues related to the production of a composite PEM should be addressed.

PHASE II: Demonstrate the multifunctionality of a candidate composite PEM’s with appropriate benchtop testing that simulate the thermal, chemical and electrical loads within an operational fuel cell. Design and fabricate a complete multifunctional fuel cell system with 30% reduced overall mass than a system with comparable power output. The cell shall be tested under a variety of conditions that mimic the service environment. This should include subjecting the system to elevated temperature, shock, and sustained usage.

PHASE III: Material solution may be applied to a variety of military electronics; including navigation and communication applications.

DUAL USE COMMERCIALIZATION: Development of composite PEM’s would have application to reduce the size of portable power generation devices that are sold commercially for use by law enforcement and consumer portable electronics.

REFERENCES:

KEYWORDS: Fuel cell, Multifunctional, Composite, Proton Exchange Membrane, Power Generating

A04-051 TITLE: Development of an Unattended Ground Sensors (UGS) Dispenser for a Small Unmanned Ground Vehicle (SUGV)

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: Henry Girolamo, Natick Soldier Systems OFW Displays POC

OBJECTIVE: To develop a small sensor dispersal mechanism for a small robotic platform, for the Future Force including the Future Combat System (FCS-SUGV) and the Objective Force Warrior programs. The dispersal mechanism shall be capable of dispersing small UGS or communications relays from a small, man-portable, (i.e., less than 50 lbs.) robotic platform. We envision a modular package that can be incorporated onto a small robotic platform that disperses small sensors, communications relays, or other similarly sized objects.

DESCRIPTION: Physical agents, such as robotic platforms, will be ubiquitous on the future battlefield, significantly lowering the risks to our soldiers. These robots must be able to not only collaborate amongst themselves but also with their manned partners. Their roles will range from scout missions, performing reconnaissance, surveillance, and target acquisition, to urban warfare or urban rescue. The human/robot interaction with these agents must be highly efficient and minimally intrusive. The interaction with the robots must not encumber the soldiers. Therefore, a dispersal mechanism is required for distributing small ground sensors, communications relays, etc. on small robotic platforms while keeping soldiers out of harms way.

A modular design is required to facilitate changing mission payloads of the robot and to accommodate different types of robotic platforms. The proposed UGS dispenser module design needs to consider tradeoffs between multiple current and future sensors (i.e. chem/bio, passive IR, acoustic, magnetic, etc.), communications relays, power from the host robot, and mission duration. The physical interaction and mobility constraints with existing small robotic platforms must also be considered (i.e. the module cannot adversely affect the capabilities of the host robot with large protruding components).

It is anticipated that this UGS dispenser module and a small robotic platform (i.e., iRobot’s Packbot) will be utilized with existing soldier wearable systems for experimentation. It is intended that the host robot should provide power, wireless communications, and an interface to the robot's host computer.

Prospective candidates should adequately address the following UGS dispenser module design features: 1) proposed design, 2) mechanical and electrical design characteristics such as physical size, power consumption, mission duration, and interface with a small robotic platform, and 3) human to UGS dispersal module interaction.

PHASE I: Conduct engineering design phase in which all components for the UGS dispenser module are identified. This should include the physical layout of the module and its interaction with the host small robotic platform and with the human, processing component specifications, and sensor specifications. Additionally, the power requirements, the processing capabilities, and how the module might affect other robot functions should be addressed. A demonstration of critical components for feasibility is strongly encouraged.

PHASE II: Develop and build a fully functional prototype UGS dispenser module that is integrated and operational with a small robotic platform.
PHASE III: Urban search and rescue is the most natural dual-use application for this technology. A small robotic platform outfitted with an UGS dispenser module would be most useful in a collapsed building environment for search and rescue. Before the area is secure enough for humans, a robot that could deploy remote sensors to detect victims and alert rescuers as to their location. Another application is for use by police units during hostage incidents.

REFERENCES:
3) iRobot’s Packbot, www.packbot.com

KEYWORDS: robotics, UGS, FCS, Objective Force Warrior, Land Warrior

A04-052 TITLE: Advanced Metal-Air Batteries

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

ACQUISITION PROGRAM: PEO Soldier Warrior, Mr. Bill Brower, 703-704-2888, william.brower@peosoldi

OBJECTIVE: Synthesize and identify new materials and chemistries for high energy metal-air batteries.

A gravimetric energy density greater than 500 Wh/kg at a power density of 15 W/kg is being sought. Good storage capability is essential but operation at sub-zero temperatures may be sacrificed as a rechargeable battery could be provided for load leveling.

DESCRIPTION: Recent research on oxygen reduction in non-aqueous electrolytes has lead to the possibility of developing metal-air batteries with energy densities greater than 500 Wh/kg. The use of non-aqueous electrolytes has allowed the use of anode materials more electrochemically active than zinc and results in metal-air cells that exhibit higher voltage and less self discharge than if a conventional electrolyte were used. These non-aqueous electrolytes can be used with lithium because they form a stable SEI (solid electrolyte interface) on lithium and still allow it to be electrochemically active. Other materials, such as ion conducting glasses or polymer electrolytes might also serve the same purpose and would allow for the use of a wider range of electrolyte solvents in a metal-air battery.

PHASE I: Identify and evaluate anode/electrolyte systems that form stable SEIs (solid electrolyte interfaces) and allow for electrochemical discharge of metals more active than zinc. Incorporate this anode/electrolyte system into prototype metal-air cells.

PHASE II: Further Explore the performance of selected anode/electrolyte/cathode systems and produce a complete prototype metal-air cell or battery.

PHASE III DUAL USE APPLICATIONS: The energy storage systems developed here are of great potential value for use with cellular phones, portable electronic devices such as laptop computers, and standby power applications.

REFERENCES

KEYWORDS: Metal-Air Batteries, Anode stabilization, Advanced Electrochemical systems
TITLE: Controllable Direct Electrical Conversion of Isotopic Radiation

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Nuclear Technology

ACQUISITION PROGRAM: PEO Soldier Warrior, Mr. Bill Brower, 703-704-2888, william.brower@peosoldi

OBJECTIVE: The theoretical investigation of the possibility of a controllable high-power, high-energy system based on a photonic reaction that can be recharged and reswitched into action, is the focus of this effort. A photonic chain reaction is by definition self-sustaining, however an auxiliary source of radiation can be used to switch the system on, so that a chain reaction is no longer required.

DESCRIPTION: This effort has been hampered by the existence of inadequate computational computer tools. For example the MCNPX (Monte Carlo Neutron Proton X) code developed by Los Alamos does not treat the possibility of a chain reaction based on the photonic triggering of a long lived nuclear isomer. The input to the computer code should include the isomer triggering cross-section, the decay spectrum of the triggered isomer, and the possible photon moderating material constituents in the reactor. The radiation problem must be married at this step to a suitable direct conversion process, based on distribution and time dependence of the source.

Reference 1 discusses the possibility of an isomer chain reaction.

The code should be an engineering code. Nuclear structure issues should not be addressed. In other words, if a triggering cross-section has been adequately measured and if the triggered isomer decay scheme has been measured these measurements are to be code input. The existence of triggering cross sections is a nuclear structure problem and should not be a part of the computer program.

PHASE I: A feasibility study that will outline the approach in detail develop a switchable high-energy-density gamma, neutron or charged particle source. The switch can be an external source causing the isomer to be switched to a ground state chain event. This radiating energy must be matched to an optimized energy conversion approach. The use of Monte Carlo Transport codes may be useful in comparing designs for systems.

PHASE II: Modify the chosen starting point code to include time dependence. Document the code to be user friendly with a thorough description of the physics behind the code. Make choices regarding which source can be switched reliably and repeatably into energy matched to power up to 10kW system loads. Risk and assessments should be based on isomer material costs, halflife, availability, activity, and specific power density.

PHASE III: Incorporate code evaluation results and design into state of the art direct energy conversion systems.

COMMERCIAL POTENTIAL: Remote site energy sources for commercial and military construction. May some day be competitive with fossil energy sources.

REFERENCES:
3) IDA (Institute of Defense Analysis) presentation titled: "An Examination of the Possibility of Controlled Extraction of Energy from Nuclear Isomers" by Bohan Balko, Jim Silk, and David Sparrow
4) George H. Miley and M. A. Prelas have many papers on direct conversion of nuclear radiation. The idea is to employ triggerable isomers as a on and off switch.

KEYWORDS: Isomers, X-Ray-Driven Gamma emission. Phot nuclear reactions, Nucleonics, Nuclear Lasers
TITLE: Miniature Actuators for Small Arms Munition Control

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: Mr. Joe Kreck, Chief of Technology Integration Division, U.S. Army Research

OBJECTIVE: Design, develop, and evaluate conceptual actuator mechanisms to provide control authority for small arms munitions as small as 20mm.

DESCRIPTION: The need for more accurate small arms munitions is critical to the survivability and lethality of the dismounted soldier. Interest in urban warfare and homeland defense require the development of smart small arms munitions as tiny as 20mm in diameter. Providing a method of maneuvering a munition toward a target of interest is essential to the development of such a weapon.

PHASE I: Design conceptual actuator mechanisms to provide control authority for small arms munitions. Establish a feasibility study of concepts to current technology, and evaluate the merits of control (maneuver) authority, reproducible movement, torque, actuation speed (minimum of 60 Hz response), volume (size), power consumption, mass, and suitability to high-shock environments. Examine most favorable concepts for a prototype of the conceptual design that would be developed into a prototype in Phase II. The concept should be refined within the feasibility study through notional integration into a munition, as well as defining any weapon system additions or requirements. Complete control of the design actuator must be addressed.

PHASE II: Develop a prototype design and control logic to evaluate performance in a realistic environment needed for small arms munitions, to include those listed in Phase I. Required military environments will include survival of 80,000 G's shock loading, while subsequently operating under military temperatures (-55 to 75 deg C), and vibration (~5 g @ < 30,000 kHz). Evaluation should culminate in an open or closed-loop demonstration of a prototype maneuver mechanism in a realistic military small arms application.

PHASE III DUAL USE APPLICATIONS: Commercial applications pertain to, but are not limited to, hobby and model enthusiasts interested in remote control airplanes, boats, and model rockets; and the actuation of robotic manipulators which may have a role in future NASA missions. Military applications such as control of small arms munitions, control of unmanned aerial vehicles, and control of aerodynamic boundary layer resulting in drag reduction and control of Air Force and Navy aircraft are possible.

REFERENCES:

KEYWORDS: actuator, control, small arms, smart weapon, linear motor, electric, high-force, MEMS, solenoid, piezoelectric, servo-motor, servo, attitude control
TITLE: Command Decision Modeling in Distributed Combat Simulation

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: PEO-Ammo, PM-ITTS

OBJECTIVE: To provide an asymmetric, non-scripted, adaptive model of battlefield decision-making to the Command, Communications, and Control Grid (C3Grid) of the Modeling Architecture for Technology, Research, and Experimentation (MATREX) distributed simulation environment.

To improve the representation of decision-making in combat simulations so that it accurately reflects aided, automated, and human processing of information and its impact on tactical decision-making.

BACKGROUND: MATREX (2,5,6,9,12,13) is a collaborative, composable, distributed simulation capability intended to support the investigation of concepts and technologies involved in the Army’s Transformation. It is a Research Development and Engineering Command (RDECOM) STO that will extend and integrate existing Joint Virtual Battlespace (JVB) and U.S. Army Research, Development, & Engineering Center (RDEC) Federation to achieve a fully multi-resolution, persistent modeling and simulation (M&S) environment. The goal of the program is to provide the Army with a set of realistic engineering models of Army systems for Simulation & Modeling for Acquisition, Requirements, and Training (SMART), that will support full spectrum analysis of system designs and operational concepts. MATREX currently requires Humans-in-the-Loop (HITL) for full experimental functionality. For MATREX tools to be executed in a constructive manner, providing statistical repeatability and validity, a decision-making component must be developed.

DESCRIPTION: The C3Grid (14,17) is a group of High-Level Architecture (HLA) federates that support entity-level simulation of military command, control, and communications (C3) within MATREX. The C3Grid interacts with OneSAF TestBed (OTB), which simulates the vehicles in which commanders travel or the assets that commanders control, at an entity level, generating orders for each entity; and receiving, aggregating, and sending commands and tactical reports from each entity, to simulate higher echelon (headquarters) units. The C3Grid has or is developing several behaviors federates to encompass different aspects of higher echelon behavior, such as synchronized maneuver, networked fires, sensor fusion, reconnaissance air service, and a federate that creates and reports a perceived Common Operational Picture (COP), of variable quality, providing the context for C3 decisions implemented by the other federates. In MATREX v0.5, the modeling of command and control behaviors is performed by the C3Grid federates using simplistic production rules executed in the Java Expert System Shell (JESS).

While the C3Grid has rudimentary models of higher echelon C3 behaviors, it does not model human performance limitations (task execution times, task performance accuracies, and task conflict resolutions), so assessment of C3 timelines and workloads has not been possible. To fulfill this need, the C3 Human Performance Model (C3HPM), developed with the U.S. Army Research Laboratory’s Improved Performance Research Integration Tool (IMPRINT – see http://www.arl.mil/hred/imb/imprint/imprint.htm and 1,3,7,11,16), is currently being integrated into the C3Grid. The C3HPM provides detailed task networks of C3 tasks that can be utilized by C3Grid’s Behaviors Federates to generate realistic timelines for the human execution of C3 tasks.

REQUIREMENTS: The rapid explosion in information circulating on the modern battlefield presents a huge challenge to the decision makers and warfighters who must plan and dynamically adapt to changing circumstance and new information, often under conditions of time pressure, uncertainty, and stress. There is also the corresponding challenge to those attempting to model the battlefield situation. The challenge in predicting battlefield outcomes rests on the ability of the model to portray the limits in information processing and decision-making of the operators and decision makers.

The production rules that are providing MATREX a rudimentary decision-making capability will become more brittle and harder to maintain as the rulebase is expanded to cover additional operational scenarios. There are other approaches to command decision-making that have arisen from the field of Artificial Intelligence (AI) (4), such as genetic algorithms (10), fuzzy logic (14), Bayesian belief networks (8), etc. Although these AI techniques were not
developed to mimic human cognitive functions, a fair approximation of human decision-making can be developed by linking the decision-model into the task networks of commander performance models in MATREX’s C3HPM component. The C3HPM would simulate human-derived task times and accuracies for the primarily cognitive tasks involved in C3, and calculate human workloads, but the AI decision-making component would provide the product (a decision, a command, an assumption, a plan, etc) of that human task. In this manner, either human or automated approaches to a task could be compared.

Although cognitive models can provide excellent representations of human capabilities, including deep models of memory, learning, forgetting, emotions, and social/cultural effects, the most important characteristics required by MATREX is simulation efficiency and scalability, rather than high fidelity human representation. Whatever technique is chosen for the decision model, it must perform in real-time or better, for a simulation scoped to the Unit of Action (with portions of the Unit of Employment), including all battlefield communications. Characteristics that are most appropriate for the decision model are the ability to represent teamwork (18), threat assessment-prediction (10), planning, and multitasking and workload management.

The ultimate outcome of the development and integration of decision models for each of the MATREX behavior federates, together with the evolving capabilities of the C3Grid to represent Network Centric Warfare (NCW), is a tool to analyze the Objective Force net-centric information management architectures. Use of this ultimate tool should provide a means to analyze the number of people and skills at each C2 node, explore where in the Grid fusion and decision-making should take place, study the effects of distributed decision-making and decentralized C2 on synchronization of forces, and discover the effects of C2-on-the-move on mission success.

PHASE I: Review the technical approaches to the simulation of decision making employed by the current MATREX federates, exploring the strengths and weaknesses of each approach. Research potential computational and architectural approaches, employing, to the maximum extent possible, actual pilot studies and laboratory comparisons, measuring the efficiency, scalability, and fidelity (to human behavior) of candidate components. Phase I should culminate in a recommended methodology for the simulation of high-level information fusion, situation assessment, and decision-making within the MATREX distributed computing environment, built on a study of MATREX requirements and a valid comparison of technical approaches. This work will take advantage of the existing capabilities in the C3Grid to model net-centric communications and low-level data fusion (organize, collate, correlate, and categorize information and compile the Common Operating Picture). Offerer will need to work closely with the developers of the C3Grid, and funds should be allocated in Phase I to establish working relationships with other MATREX developers to achieve consensus as to the design and software interfaces of the decision component. The Phase I effort should include an evaluation of technical feasibility (and cost) of full component development, an estimate of effort required from other MATREX developers or subject matter experts, and changes or extensions to IMPRINT or the C3Grid required to implement the decision model.

PHASE II: Building on the theoretical understanding from Phase I, design, prototype, and develop a real-time MATREX situation understanding and decision-making component fully integrated into the MATREX distributed environment. The component will include modules for high-level information fusion, situation assessment, and decision-making, focusing on a networked fires application. Perform software verification and validation, optimize algorithm design based on MATREX test data and feedback, and provide complete documentation of algorithms and the software architecture as required for inclusion in MATREX distributions.

PHASE III DUAL USE COMMERCIALIZATION: The distributed decision model is applicable to other information-intensive industrial and commercial fields, such as remote sensing, automated manufacture, medical systems, robotics, and image processing. Just as it can become a part of other military distributed simulation environments, it can be commercialized as a part of the recently developed, commercially available distributed simulation environments, such as CAE’s STRIVE.

REFERENCES:

KEYWORDS: Command Decision Models, Decision-making, Situation Assessment, Situation Understanding, Threat Prediction, Distributed Simulation, HLA, Network Centric Warfare, Networked Fires, Synchronized Maneuver

A04-056 TITILE: Bio-Based Nano-Electronic, Electro-Optical, or Semiconducting Device Materials

TECHNOLOGY AREAS: Materials/Processes, Electronics
OBJECTIVE: To build upon recent developments in the synthesis and processing of biologically-inspired (or derived) templating/assembly of micro-scale and nano-scale inorganic materials for the construction of simple electronic, electro-optical, electro-mechanical, photovoltaic, or semiconducting devices.

DESCRIPTION: The overall approach is inspired by the recent discovery and development of at least three different bio-based systems of self-assembling proteins, peptides and their biomimetic (synthetic) analogs that have been shown to catalyze and/or template the growth of semiconductor wires: the discovery and harnessing of enzymes that both catalyze and template the nanostructure-directed growth of a wide variety of photovoltaic and semiconductor metal oxides; the use of peptides selected by phage display to template the growth of semiconductor quantum-dots; and the use of prion-type proteins to self-assemble or template similar nanostructured materials. A number of workers are beginning to characterize the electronic, optoelectronic and photovoltaic activities of these structures and materials. Taking advantage of the fiber-like properties of these semiconductor micro- and nano-wires to learn how to effectively process and then make useful devices are the next steps.

PHASE I: Demonstrate the ability to synthesize and process a biologically inspired (or derived) material useful in the manufacture of electronic, electro-mechanical, electro-optical, photovoltaic, or semiconducting devices.

PHASE II: Integrate the material(s) developed in Phase I into a micro-scale electronic device (less than 1 micrometer along at least two dimensions). Ideally such devices would be prototypes of useful components not fashionably by any other process, and/or self-repairing, repairable under field conditions, or faster to construct than existing devices of comparable performance. A demonstration that the manufacturing process is more economical, environmentally benign, less apt to generate hazardous waste, or consume less energy is also desirable.

PHASE III DUAL USE APPLICATIONS: Such a process would serve both DoD biotechnology goals and provide the developer with a technology for producing unique electronic components not fashionable economically by other methods.

REFERENCES:

KEYWORDS: biotechnology, electronics, sensors, nanotechnology, phage display, enzymes, microelectronics

A04-057 TITLE: Signal Enhancement Technology for Advanced Microplasma-Based Force Protection Sensors

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PEO-Ammo, PM-ITTS

OBJECTIVE: To develop innovative technologies to enhance the chemical signatures detected by the Laser Induced Breakdown Spectroscopy (LIBS) sensor. Such improvements will allow for the development of ultra-compact
LIBS sensors for a wide range of field applications such as air duct protection from chem-bio threat or placing lightweight LIBS sensors on small robotics as well as unmanned fixed wing and rotorcraft platforms (e.g., Future Combat System (FCS) robotics military platforms such as the Armed Robotic Vehicle (ARV) and Multifunctional Utility/Logistic Platform (MULE)).

DESCRIPTION: LIBS is a major new field-sensor technology with unprecedented performance attributes (Refs. 1-4) including: (1) real-time response, (2) high sensitivity (nanograms), and (3) can detect chem/bio agents, explosives, toxic industrial compounds (TICs), and other hazardous materials. In addition, LIBS can be used as a point detector, or in a standoff mode. The LIBS components (laser, spectrometer, power supply, etc.) are all inherently rugged and can be made into compact packages. Currently the Army is developing a field-portable (backpack) LIBS sensor with a handheld laser and broadband spectrometer in the backpack. LIBS sensors could be very useful in many more applications if the package could be made much smaller. For example, LIBS could be used as a continuous air duct monitor for chem/bio agents or could be placed on small robotics platforms (both ground and airborne) to do field analysis of materials even at distances up to 100 meters. A major limitation of current technology is the lack of sensitivity of compact array detectors to particularly weak signals. Examples of such weak signals include microplasmas created at some distance from the laser source, or those that are generated by very small microlasers that produce microJoules per pulse yielding especially small microplasmas. Traditionally, Intensified Charged Coupled Detectors (ICCDs) would be used to detect such weak signals, but current ICCDs are much too bulky, too expensive, and too fragile for field use in small sensors. Novel ideas for much higher quantum efficiency Charged Coupled Detectors (CCD) arrays and/or compact and inexpensive intensifier technologies are sought. Another innovative approach for LIBS signal enhancement could involve the use of microwave plasmas. Currently the LIBS plasma-producing laser has a very short pulse duration (approximately 10 nanoseconds or shorter) which results in a fairly short microplasma emission event which lasts approximately 10 microseconds. However, the signal from the target elements could be significantly stronger if one could generate a longer-lived plasma (e.g., 1 second instead of 10 microseconds). In this plasma the elements would undergo many more excitation/de-excitation cycles leading to stronger signals. Technologies currently exist where parts-per-billion concentrations of metals are detected using microwave driven plasmas. Thus, the notion would be to incorporate microwave plasma technology with LIBS in a single sensor. Applications for bio-aerosol detection and identification are envisioned.

PHASE I: Phase I work will include: (1) a demonstration of technologies that significantly enhance the LIBS analytical signals and (2) a theoretical qualitative analysis in a form of a report of the physics behind the signal enhancement and possible further improvements that could be made.

PHASE II: In this phase a fully operational prototype of a portable enhanced LIBS system will be built, tested, and delivered to the Army for further testing. This innovative LIBS system will be incorporated into a hand-held unit suitable for field applications or be configured for bio-aerosol detection in air ducts. The final report will include data on signal enhancement, cost, and reliability of the new technology. Consultation will take place with the LIBS research underway at the Army Research Laboratory at Aberdeen Proving Ground.

PHASE III DUAL USE APPLICATIONS: Design and development of significantly improved LIBS compact sensor systems will greatly expand the use of LIBS for health (e.g., hospitals), environmental, and security applications.

REFERENCES:
2) See articles on explosives and bio-materials detection and identification in above.
4) See http://www.arl.army.mil/wmrd/LIBS

KEYWORDS: Chemical-Biological Real-Time Sensor, LIBS
TITLE: Rifling of the Inner Surface of Ceramic Tubes

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: We are expecting a letter of support from PM Guardian.

OBJECTIVE – The objective is to introduce rifling on the inner surface of a ceramic tube. The primary interest to the Army is for gun barrel applications.

DESCRIPTION – The U.S. Army Research Laboratory is currently assessing the feasibility of ceramic gun barrels in an attempt to provide a significant increase in barrel life and a reduction in weight for smaller caliber systems. This investigation spans a range of calibers from 5.56mm rifle to 155mm artillery. Most systems of interest within this range of calibers use rifling to impart spin to a projectile to insure stable aerodynamic flight that helps promote accuracy. The potential for utilizing ceramic tubes may be limited by the ability to introduce rifling on the inner surface of a ceramic tube. Ceramic components with complex geometries are typically fabricated using conventional diamond grinding methods which may introduce flaws into the ceramic that could degrade the performance of the component. In order to fully realize the potential benefit of a ceramic gun barrel, it is necessary to demonstrate a procedure having the ability to introduce rifling without severely degrading the structural robustness of the ceramic while holding geometric tolerances so uniform and consistent land height and groove depth may be maintained.

PHASE I – Study and describe as feasible a procedure to introduce a rifling geometry on the inner surface of a ceramic tube. The ceramic of interest shall be from the silicon nitride family of materials with a density of > 98% of theoretical, although other materials with acceptable characteristics could be considered. In this study the tube shall nominally have a 33mm outer diameter and a length of 100mm. A successful process will introduce a straight rifling profile on the inner diameter of the ceramic tube resulting in 8 lands and grooves being imparted. The goal of this project is to demonstrate progress toward achieving the following rifling pattern: land diameter of 25mm, groove diameter of 26mm, land height of 0.5 mm, groove width of 4.3mm, and land width of 3.8mm. A detailed drawing showing tolerances of this rifling geometry can be obtained via Ref 1. The proposer will be expected to characterize the rifling to insure geometric consistency of the rifling along the length of the tube, thus validating the success of their recommended process. All findings will be included in a report to be delivered at the end of the effort.

PHASE II – Continue and improve the procedure for introducing the rifling on the inner surface of ceramic tubes started in Phase I. This Phase II project is expected to produce a proof of principle demonstration of the rifling method used in Phase I but on longer length ceramic tubes. The geometric rifling dimensions will be the same as in Phase I but a uniform rifling twist ratio of 10:1 (1 complete turn of rifling in 10 calibers (250mm) of length) shall be introduced. The proposer shall conduct mechanical property evaluations of the ceramic tubes sufficient to demonstrate that the bulk properties are not significantly degraded by the rifling when compared to the same mechanical property data for non-rifled ceramic tubes. Based on the data from these evaluations attempts will be made to optimize and improve the procedure to minimize degradation of the ceramic tube. A highly successful SBIR Phase II would deliver two prototype 250mm rifled ceramic tubes at the end of the first year to the US Army Research Laboratory (ARL) for further evaluation, with an ultimate program goal being to deliver four prototype 500mm rifled tubes to ARL at the conclusion of the Phase II effort. Although aggressive, this delivery schedule is encouraged to prompt an accurate demonstration of this important technology.

PHASE III – As this technology matures and provides the expected results, the procedures developed for introducing rifling will then be scaled and applied to small caliber gun systems such as the 5.56mm, 7.62mm and 50 cal.

DUAL USE COMMERCIALIZATION: – The development of a rifled ceramic gun barrel would have applications to other caliber gun systems, providing better quality equipment for use by our police and security agencies. Commercialization opportunities may also exist for the applications of this technology in specialized wear parts and dies, for use through-out the constantly evolving ceramics industry.
REFERENCES
1) To obtain a schematic of the rifling geometry with the exact dimensions and tolerances send a fax request to the following number (410) 306-0759. Please include “Rifling of the Inner Surface of Ceramic Tubes - SBIR” in the TO: line of your fax.

KEYWORDS: Rifling, Ceramics, Gun Barrel Liner

A04-059 TITLE: Macro-Fiber-Composite Power Module

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: We are expecting a letter of support from PM Guardian.

OBJECTIVE: Design and fabricate an electronics power module for self-contained operation of interdigitated electrode (IDE) piezo-composite actuators. The module must be low weight, compact, capable of recycling energy from discharging piezo elements, and can be operated from conventional vehicle input power sources (e.g., 28V avionics, or 12V vehicle power systems). The packages should be self-contained (i.e., little to no assembly required), and have all necessary electrical connectors, e.g., high-voltage output connectors to power MFC actuator components and input connectors for low-voltage control signals. Prototype packages/modules should also be as “flight-like” or fieldable as possible, i.e., capable of being easily installed within typical aircraft airframes or land vehicle bodies (e.g., secured or bolted to a bulkhead or frame).

DESCRIPTION: The objective of the LCAR STO is to develop individual blade primary control on rotorcraft without a conventional swashplate. One of the most promising technologies for LCAR that has been demonstrated to date is the use of active blade twist control, which is achieved by embedding IDE fibers in the composite material of rotor blades. High voltage is applied to these actuators to obtain a high-frequency twist deformation that enhances rotor performance and reduces helicopter vibration.

Recently, actuator development studies using IDE piezocomposite-based technologies have been conducted in rotorcraft technology demonstration efforts within NASA Langley Research Center and the Army Research Laboratory Vehicle Technology Directorate (refs. 1-3). As these studies were aimed at the demonstration of the technology in a laboratory or research environment (i.e., lab or benchtop testing), sizing issues with respect to the power and conditioning for the actuators were not a principal focus. However, to achieve successful integration of such actuation concepts on full-scale, fielded systems where constraints regarding payload size and weight, as well as manpower required to install and operate such devices are significant, pre-assembled modular electronics packages are desired which offer minimal size and assembly yet feature sufficiently robust power for controlling interdigitated electrode piezocomposite-based actuators.

Early research and development in IDE piezocomposite devices focused upon the fabrication and testing of laboratory proof-of-concept actuator packages (refs. 4-6). Researchers at NASA Langley Research Center and the Army Research Laboratory Vehicle Technology Directorate have subsequently developed advanced, higher-performance IDE piezocomposite actuators that utilize low-cost assembly practices and precision-machined piezoceramic fiber components (refs. 7-9). All IDE piezocomposite actuators have low electrical power and current requirements and high mechanical output work energy densities. However, the IDE architecture used with current generation devices still requires relatively high voltages for optimal performance. In the laboratory, large, general purpose high voltage power amplifiers and instrumentation can be used for basic IDE piezocomposite applications research and development tasks. However, to obtain the greatest benefit in future fielded applications, low weight, compact, application-specific power electronics systems, suited to the driving requirements of IDE actuator devices (i.e., high voltage, low current), will need to be developed.
Power electronics packages developed under this study should deliver maximum electrical power while minimizing package volume and mass. They should have an operating output voltage range of approximately -500V to +1500V, and an output operational bandwidth from DC to at least 1kHz, with no more than 3dB of gain attenuation and minimal signal distortion or phase lag (<1%) over this range. Typical 28V or 12V vehicle power sources should be assumed for the package design. Peak output power and current can be determined as a function of appropriate MFC actuator capacitive loads based on a reference capacitance of 2.5 nF per square inch of MFC actuator surface. Scalability of the power electronics to various capacitive load ranges should be demonstrated as well, e.g., size/mass for driving 1 cm² of actuator area, 100 cm², 1 m², 10 m², etc.

PHASE I: The Contractor shall define a preliminary design and provide a working breadboard layout of the desired integral electronics package design, and demonstrate basic functionality by driving representative MFC actuator capacitive loads. The Contractor shall provide detailed drawings of the design concept.

PHASE II: The Contractor shall develop a final design of the proposed electronics package and fabricate a prototype, “flight-like” power electronics package for an appropriate MFC actuator capacitive load. The Contractor shall demonstrate the wiring and connectivity of the prototype electronics module using existing commercially-available MFC actuators and conduct appropriate benchtop tests to demonstrate functionality of the prototype module with regard to desired voltages, currents, and actuation frequencies.

PHASE III DUAL USE COMMERCIALIZATION: Future rotorcraft vehicle systems will require the aforementioned power and conditioning capability for MFC actuators, potentially creating a large and continuing market for electronics systems of small size and weight for rotary-wing and aircraft systems. Additional applications requiring lighter-weight small-profile powering packages for MFC applications include spacecraft (vibration suppression; shape changing, dynamic structural health monitoring), accelerometers; and automobiles (speakers, interior noise abatement). The Contractor shall refine the electronics package for commercialization.

REFERENCES:

KEYWORDS: rotorcraft, interdigitated electrode (IDE), piezo-composite actuators, Macro-Fiber-Composite Power Module
TITLE: Vehicle-Based Detection and Neutralization Methods-Devices for Roadside Bombs and Hard Wired Munitions

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: We are expecting a letter of support from PM Guardian.

OBJECTIVE: To develop vehicle-based techniques and devices that can detect and neutralize: 1) roadside explosive charges that are initiated remotely or through hard-wire, and 2) large caliber munitions (100 to 155-mm) that are detonated remotely or through hard-wire. Those detection devices are to be vehicle-based and integratable into/onto Army vehicles. In addition, they should strive to be highly discriminate, reliable, and avoid giving false alarms.

DESCRIPTION: One must distinguish between the conventional land mine clearing/detecting scenario and the present case where explosives are on the side, and not in front of the vehicle and may be as close as 10 ft or less from the vehicle. Also, it is desired to have detection capability of a large distance from the vehicle as large as 400 ft, to allow time for reaction. The detection result may be fed to the inside crew both in visual (say, red flashing lights) as well as high audible warning sound. Detection and neutralization methods may include electrical wave jamming, white noise (electronic or acoustical), radar, microwave, laser, millimeter waves, and magnetic field, among other methods. The references cited are for background knowledge about the systems in use by the military, both foreign as well as by the U.S.

PHASE I: To study, investigate, and recommend, the best candidate methods and devices for: a) detection and b) neutralization of the two threats:

1- Roadside explosive charges of commonly used explosives (such as TNT, Comp B, C-4, Pentolite, among others). These charges may be bare, enclosed in wooden or metallic containers, buried or just camouflaged and placed above ground.

2- Roadside large caliber munitions (100- to 155-mm) that are detonated wirelessly or through hard-wire. They may be hidden under sand/soil, small rocks, or left bare on the ground. Detection needs also to be made for long thin wires shallowly buried in the ground or totally bare on the ground. Small, expendable back-pack unmanned aerial vehicle with sensors/cameras may be explored as a possible platform being launched from the vehicle. Detection methods may cover traditional areas such as magnetic, optical, infrared, millimeter wave, acoustical, among others, as well as novel methods. Neutralization methods may also cover traditional methods such as laser, millimeter wave, optical, radio frequency, frequency jamming, and frequency white wash, among others. Unconventional innovative and novel methods should be investigated. Low-tech remote detonations by devices such as automobile remote door-lock signal or garage door-opener signal, and the like, are also of interest since they are widely available for use in causing detonations in urban setting.

Best method for each of the given two threats needs to be presented with its estimated performance (based on prior use, if known.) Therefore, the study should present at least four concepts of methods and their corresponding devices of detection/neutralization together with a list and the attributes of the other non-selected methods as a comparative reference. Assumptions, properties, limitations for each method/device investigated should be listed. Estimates for the size, weight, and dimensions, of the devices should be made and listed. Considerations for how the devices will be mounted on the vehicle need be explored. The basic parameters for the study may be considered as follows. The vehicle as a platform for the devices is considered to be moving at 20 mph (30 ft/s). Detection distance should be as large as possible, preferably larger than 400 ft radius, but not smaller than 100 ft. Probability of detection should be as high as possible. Probability of providing false detection should be as low as possible. Wires of diameter as small as 0.04 inch (1 mm) should be detected.

PHASE II: To produce and deliver prototypes for the detection and neutralization devices after actual testing: 1) in laboratory setting, then 2) in an idealized real field setting. The devices have to be integratable into Army ground vehicles and retested for their capabilities after being installed on the vehicle. Detection probability should be as high as possible and so is the neutralization probability. Final test with live explosives and munitions will be final performed.
Assumptions, properties, limitations of all items/methods/devices studied should be listed. Weight, cost estimates per copy should be estimated and given.

PHASE III DUAL USE TECHNOLOGY: Efforts are to be made to adapt the devices developed in Phase II for actual commercialization and use in the field. Also, hardening of the devices for use in rough environment shall be pursued. Efforts to manufacture and produce those devices in sufficient numbers to meet the demand of the Army, and other possible non-defense customers, including the UN shall be made. Commercialization efforts should explore the detection and neutralization of land mine fields in war-torn countries around the world. Investigate possible applications to civilian application areas like airports, seaports, large public buildings for possible use for explosives detection.

REFERENCES:

KEYWORDS: explosives detection; explosives neutralization; remote detonation; hard-wired detonation; wireless detonation; munitions detonation; urban warfare; ambushes; sensors; vehicle-based devices

A04-061 TITLE: Studies of Stochastic Pursuit-Evasion Differential Games with Multi-Pursuers and Multi-Evaders

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: The purpose of this SBIR project is to solicit the development of a stochastic pursuit-evasion differential game that involves multi-pursuers and multi-evaders. The study shall include problem formulation and characterizations and computational algorithms of strategies that optimize the time for capturing all evaders.

DESCRIPTION: It is evident that the deployment of mobile interactive agents, such as robots and unmanned aerial vehicles, has become increasingly important in the surveillance and/or pursuits of adversary forces in the current and future military operations. These mobile agents are often equipped with sensors and wireless communications capabilities to coordinate among the friendly agents (the pursuers) in order to pursue and destroy the adversary forces (the evaders). In order to achieve these goals in an optimal manner, it is essential that the issues that involve the group coordination and formation (see [7]) be resolved optimally under various physical constraints (see [1]) internal and external to the team of pursuers. Currently, the heuristic studies of group coordination and formation of these interactive agents in discrete time environment have been done in an ad hoc manner (see [2]). However, the problem formulation and the characterization and computation of optimal pursuit strategies with multi-pursuers and multi-evaders in continuous time, as well as in random environments, remains to be resolved. The mathematical study of deterministic differential pursuit-evasion games with single pursuer and single evader began in the 1950s at Rand Corporation for the purpose of predicting the outcome of simple warfare. With the advent of mobile agents, such as robots and unmanned aerial vehicles, and their deployments in modern military operations at the tactical and strategic levels, the need for systematic studies of stochastic pursuit-evasion differential games with multi-pursuers and multi-evaders become increasingly important. Due to its mathematical difficulty in the formulation and analysis of information flow patterns and issues related to the observability of the state variables and randomness in the environments, the progress made in this area has so far been very limited. The purpose of this project is to re-energize the research efforts and to call for involvement of the private sector in these studies that will benefit the
DoD and the high-tech industry in terms of the commercialization of computational algorithms for the optimal pursuit strategies. As an anticipated spin-off, the defense industry will prosper by being able to design and manufacture robots and unmanned aerial vehicles that possess the functionality to carry out optimal pursuit-evasion strategies. The results of this research will also put the Army at the cutting edge in tactical and strategic planning and ensure the victory of military operations. In particular, the Army agencies such as CISD/ARL and SEDD/ARL and Army SOCOM will be among the beneficiaries of this research. The mathematical tools and techniques needed for the research may include newly developed robotic group coordination and formation (see [7]) and centralized and decentralized control (see [4] & [5]) with complete or incomplete information. Mathematical developments in the areas of nonlinear filtering are relevant and could be applied to solve some pursuit-evasion problems under noisy or incomplete observations. With the recent development of viscosity solutions for the Hamilton-Jacobi-Bellman (HJB) equations and their numerical solutions in the areas of stochastic control (see [6]) and some yet-to-be-developed mathematical tools, it is feasible that these results can now be extended to systematically solve stochastic pursuit-evasion differential game problems.

PHASE I: The phase I research of this SBIR project shall focus on formulation of the stochastic differential pursuit-evasion game problem that involves the coordination and supervision among the friendly agents. It is suggested that the problem formulation include major components such as the stochastic state and observation equations, admissible control policies for both the friendly and adversary forces and the performance index that take into the account of capture time (i.e., the time it takes to destroy some or all adversary agents). Based on the foregoing analysis, Phase I should result in a design for the pursuit-evasion game tool.

PHASE II: In Phase II, the small business should take the design developed in Phase I and produce the pursuit-evasion game tool prototype. The following issues should be considered when developing this tool. Note that these issues are not meant to be all inclusive nor are they intended to be the only method to achieve the intended results:

a) Establish the existence of Nash-type equilibrium for the value of the differential game.
b) Derive the dynamic programming equations and/or maximum principle.
c) Verify the regularity of the solution of the above equations. In the case where the regularity of the solution is lacking, obtain the solution in a weaker sense.
d) Catalog the characterization of optimal pursuit-evasion strategies.
e) Obtain numerical solutions of the equations obtained above and their corresponding optimal pursuit-evasion strategies.
f) Develop computational algorithms for optimal pursuit-evasion strategies.

PHASE III DUAL USE COMMERCIALIZATION POTENTIAL: The research and development of new computational algorithms for stochastic pursuit-evasion differential games will contribute to the improvement and cost-savings of training soldiers and agents and battlefield simulation of military operations. In addition, the firms who perform the research can commercialize its end products (such as software and hardware) to the multi-billion-dollar computer game industry and general public for entertainment purposes.

REFERENCES:
KEYWORDS: Stochastic pursuit-evasion differential games, formation and coordination, information flow patterns, noisy and incomplete observations

A04-062 TITLE: Solid Sorbent Trap for the Safe Handling of Chemical and Biological Contaminated Materials

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: The objective is to identify and explore innovative technologies for the collection, neutralization, and preservation of battlefield materials and evidence of a chemical and/or biological agent. The material will be used to capture a broad range of such agents (including toxic industrial chemicals), mitigate their hazard to field and laboratory personnel through neutralization of the agent(s) to non-toxic by-products with no off-gassing, and retain the reaction products such that they can be used to identify the original threat agent. The nature of the original chemical or biological warfare agent would be ascertained by the chemical signature left by the reaction products from agent neutralization.

DESCRIPTION: Present field monitoring devices have focused on specific threat agents, but it is increasingly recognized that a wide range of toxic industrial chemicals (TICs) and materials (TIMs) may pose hazards to troops. This effort will complement currently available chemical detection systems by providing low hazard identification of chemical and biological warfare agents giving the military an important capability that is not presently available. Of specific interest is functionality of the sorbent material with threat chemical agents (HD, GA, GB, GD, and VX), blood agents (AC and CK), lung damaging agents (CG, halogens, phosgene), category A and B biological agents, and toxic industrial chemicals.

The technology should simultaneously identify the use of multiple agent species without cross interference. It should be possible to remove the decontaminated (non-toxic) remnants of the original chemical or biological warfare agent from the sorbent material either by thermal desorption or chemical extraction. An alternative for the final analysis of the original CB warfare agent could be an “in situ” method such as solid state NMR or similar technique. In this case, it is crucial that the sorbent material not interfere with the analytical method. Ideally, the technology would be amenable to the capture of the chemical and/or biological agent in solid, liquid, or gaseous form as well as from air, water, and soil. The sorbent should be able to operate under all environmental and climate conditions.

PHASE I: The proof of feasibility phase will focus on laboratory experiments investigating signature behavior of chemical and biological warfare agents with the sorbent material. It will be necessary to demonstrate capture and retention of these materials with the proposed sorbent. Several methods of analysis should be evaluated to determine if a particular agent can be better detected under those conditions. Concurrently, attention to the development of standard protocols and handling should be addressed. Proposed systems should be evaluated for the exposed sample stability and signature viability.

PHASE II: The purpose of this phase is to demonstrate the utility of the prototype sorbent material for use with a broad range of CB and TIC agents. It will be necessary to demonstrate the neutralization for the CB/TIC agents as well as determine their specific reaction products. Detailed development of the neutralization chemistries will be needed in order to minimize or eliminate false positives. Additionally, the final analysis of the neutralized materials should be demonstrated to confirm/verify detection capability under various environmental conditions as well as the sensitivity, selectivity, and range of capability of the sorbent. This portion of the program will require the development of a prototype sorbent that will be employed in blind-test experiments.

PHASE III DUAL USE COMMERCIALIZATION: The Phase III effort will involve further demonstration and validation for transition to a fielded capability. Agent detection technologies developed in this topic area have potential application to trace analysis of a wide range of volatile organic chemicals, safety detection in municipal water distribution systems, novel separations materials for industrial chemical processing, and bio-medical
applications. Ultimately this technology may be used in real-time chemical sensors and could be used by civilian emergency response and criminal investigation units.

REFERENCES:

KEYWORDS: Chemical agent detection, biological agent detection, toxic industrial chemicals, forensics, adsorption, sorbent

A04-063 TITLE: Identification and Characterization of Molecular Inhibitors of Cognitive Performance

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To identify and characterize molecular inhibitors of cognitive performance.

DESCRIPTION: Genetic and biochemical understanding of human molecular networks has increased exponentially over the last decade. While early efforts focused on simple single gene disorders, the availability of whole system genomics and proteomics analyses as well as high throughput mutagenesis, has enabled the identification and characterization of multigenic complex states. Genetic components of traits involving multiple genes, environmental influences, and variable phenotypes, such as obesity, susceptibility to deafness, cognitive performance, and diabetes are starting to be identified. Identifying and understanding of the molecular defect or variation enables the development of nutritional or pharmacological countermeasures to improve cognitive performance.

The research funded by this SBIR will enable an integrated and predictive understanding of the molecular reactions that drive the human brain. Specific gene sequences and gene expression patterns will be identified that enable optimal cognitive performance. The chemical nature of the proteins encoded by these genes, how they are regulated and how they interact with other proteins, will elucidate how to prevent conditions that interfere with optimum cognitive function, and how to improve cognitive function through nutritional or other noninvasive means. The ultimate goal is to use genetics and genomics to understand the molecular mechanisms that control brain processes, and to use this information to enable persons to function at their cognitive optimum.

PHASE I: The investigators will develop or use an already existing system to begin to identify genes that have an effect on cognitive performance. The work may be limited to cognitive performance under realistic stressors such
as physical stress, sleep deprivation, or other stressors that are often encountered by troops in battlefield situations. The model organism must exhibit measurable cognitive performance, and could include organisms such as birds or rodents.

PHASE II: The investigators will undertake a comprehensive genomic analysis to identify gene involved in and required for optimal cognitive performance. Identified genes and their corresponding proteins will be characterized, and this knowledge will be used to develop compounds or nutritional or other non-invasive intervention strategies to optimize cognitive performance and to maintain optimal levels of cognitive performance under battlefield conditions. Specific research objectives include: 1) identification of molecular polymorphisms that are associated with altered capacities, 2) identification of changes that occur at the genomic or proteomic level that affect cognition, 3) test that alterations in expression or sequence improve performance in a model organism, 4) characterization of the molecular factors to identify functional and regulatory pathways, and 5) identification of nutritional or other strategies to optimize and maintain human cognitive capacity based on the molecular mechanisms discovered. This work will focus on healthy individuals, whose cognitive abilities are uncompromised by age, medical problems, or disease, with a clear goal of optimizing cognition in the young healthy population that populates the U.S. Armed Forces.

PHASE III DUAL USE APPLICABILITY: The impact of sleep deprivation on cognitive performance is well documented. Civilian concerns are most focused on cognitive errors made by fatigued medical personnel, pilots, and automobile drivers. Fatal errors made by these three groups are well documented and are a widespread public concern. Improvement of cognitive performance in sleep-deprived persons would have broad beneficial impacts on civilian health and longevity.

REFERENCES:

KEYWORDS: human, cognition, cognitive, performance, brain
This project aims to design and develop methodology and software tools that can be used in the mobile communication system. Specifically, methods to detect routing anomaly and system faults are of special interest. Another part of the effort is to develop an advanced visualization tool to assist in the interpretation of network detection and data analysis. The tool developed should allow commanders to view the status of the communication system, and to be alerted to any system fault or anomaly.

PHASE I: Analyze fault and anomaly detection needs of mobile ad hoc networks. Research and develop advanced fault analysis and anomaly detection methods and algorithms for mobile ad hoc networks. Propose the most promising detection and analysis algorithm and methodology for mobile communication system. The Phase I deliverable includes a detailed report on the needs of fault analysis and anomaly detection technology for mobile ad hoc communication systems, a summary of existing detection technology, and a proposed new solution. (Note: This SBIR only concentrates on mobile ad hoc wireless system. Proposals on general wireless system such as wireless LAN or cellular wireless are not solicited.)

PHASE II: Based on Phase I analysis, Phase II needs to implement a fault analysis and anomaly detection system prototype. Further, the detection and analysis engine needs to be tested and verified. Using a specific mobile ad hoc routing protocol, such as Ad hoc On Demand Distance Vector (AODV) routing, the PI needs to develop a series of test scenarios by creating various types of faults and anomalies. The detection system needs to be tested against these cases. As part of the Phase II efforts, a visualization tool needs to be developed which can be used to display the results of analysis and let users analyze and interpret the captured network data.

PHASE III: Focus on the commercialization of the technology developed in Phase I and in Phase II. The analysis and detection system can easily be adopted into commercial products. For example, the analysis tool can be used to monitor 802.11 wireless LANs, which have many similarities to the wireless ad hoc networks. The visualization tool can be applied to common analysis data sets and be easily integrated into existing commercial network management tools.

REFERENCES:

KEYWORDS: Mobile ad hoc network, Fault and Anomaly Detection and Analysis, Visualization

A04-065 TITLE: Innovative Hosts for Bacteriorhodopsin-Based Optical Memory

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective of this SBIR is the development of thermal and photochemically stable, highly efficient, biobased membrane films for embedding bacteriorhodopsin for exploitation in ultrafast optical, reversible holographic memory, nonlinear optical filters, and pattern recognition bioelectronic systems.

DESCRIPTION: Bacteriorhodopsin (BR), a photon-driven proton pump, is a transmembrane protein found in the purple membrane of the archaeon, Halobacterium halobium. The 26kDa BR is organized with polyrenoid lipid chains in the hydrophobic moiety on a highly ordered two-dimensional lattice in the membrane. Enormous interest has been generated by application of the structural and dynamic properties of the BR protein in bioelectronic devices. Embedding bacteriorhodopsin in membrane films is essential to achieve functionality of such devices. Although some prototype devices have been fabricated, instability of the membranes is acknowledged as a major impediment to the development of BR-based devices. Whereas there has been much biotechnological
experimentation on the properties and functionalities of the BR protein, comparatively little attention has been paid to the critically important supporting lipid matrices in which BR functions. Archaeal membranes consist predominantly of isoprenoid chains ether-linked to an alcohol such as glycerol. These isoprene structures are unique and are not prone to decomposition at high temperatures. That isoprene molecular fossils have been found in geologic Miocene deposits attests to the extreme durability and stability of these structures. In viable organisms BR functions at high efficiency at temperatures as high as 140 C, in near-saturating concentrations of salt, and in highly acidic environments. Specific lipids of the purple membrane are required for normal bacteriorhodopsin structure, function, and photocycle kinetics. At ambient temperatures, the membranes are in a liquid crystalline state that provides optimal functioning of the BR. Adaptations of the membrane lipids allow maintenance of the liquid crystalline state even as the indigenous conditions change. Nevertheless, as a consequence of light absorption, BR initiates a photocycle through structurally distinctive conformations, causing tractable optical and electronic properties of the protein. The characteristics of the lipids in the membrane dictate the large-amplitude motions of BR, and by consequence the broad utility of BR in bioelectronic devices.

The research to be developed under this SBIR would have military and civilian importance. Some of the bionanotechnological applications that are anticipated include: ultrarapid optical data acquisition with parallel processing capabilities; extreme high density holographic three-dimensional data and image storage; unique optical filters; highly sensitive photodetectors and sensors; and color-transitioning security links for forgery and counterfeit prevention. Adapting natural membranes or engineering alterations in those structures would have significant advantages over the artificial membranes that are currently employed. The naturally derived membranes would be biodegradable, eliminating the necessity for the disposal of products that would be toxic or recalcitrant to decomposition. Another major advantage would be the broad utility of the membranes with a variety of bioengineered bacteriorhodopsin molecules. Using site directed mutagenesis it is known that the molecular and physical properties of the protein molecule can be altered. Thus, with the molecular biological "tailoring" of bacteriorhodopsins for specific phototropic properties, it will be possible to optimize the photocyclic intermediates for distinctive properties in particular applications utilizing natural membranes.

The research to be conducted under the auspices of this SBIR would focus on the unique properties of the archaeal lipids that provide the high efficiency of the bacteriorhodopsin under normally adverse conditions.

PHASE I: The collaboration and integration of specialists in the fields of biophysics, molecular biology, microbiology, natural products chemistry, and materials science would be utilized to identify the most suitable organisms to utilize for the production of adequate quantities of archaeal membrane lipids for analysis and modification within the structure of the SBIR. Several microbial membranes would be prepared to determine which would serve best as a platform for bacteriorhodopsin activity. An assessment would be made of the optimal membrane properties that would be most suitable for BR operation in bionanotechnological devices.

PHASE II: The information gained in Phase I would be used to develop thermal and photochemically stable, highly efficient, biobased membrane films for embedding bacteriorhodopsin. There would be consultation with Army scientists to determine reasonable field physical and environmental operational ranges for devices to be developed. Synthetic and biological membranes with lipid compositions that would function within those ranges would be prepared. Measurements would be made of the stability of the membranes, the electrical and ionic insulating capacities, and the activity of native and "tailored" rhodopsin in generating and sustaining ionic gradients. The development of agents for stabilizing membranes, yet preserving the activity of bacteriorhodopsin, would be pursued. Functional films as models for nanoscale devices would be fabricated.

PHASE III DUAL USE APPLICATIONS: The fabricated membranes would be tested and developed for field application in various devices. In collaboration with appropriate Army laboratories, potential applications for unique military operations would be developed. Formulations and fabrication of membranes with unique biophysical properties would be achieved. These could be used commercially in many applications, including ultrafast optical, reversible holographic memory, nonlinear optical filters, and pattern recognition bioelectronic systems, etc.

REFERENCES:

KEYWORDS: Bacteriorhodopsin, Purple Membrane, novel hosts, bioelectronic devices

A04-066 TITLE: Integration of Airborne Doppler Lidar Data into Real Time Analysis and Fusion of Battlefield Weather Conditions

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Battlespace

OBJECTIVE: Obtain real time knowledge of three-dimensional wind fields and remotely track aerosol clouds using new airborne Doppler lidar technology.

DESCRIPTION: Real time knowledge of three-dimensional wind fields and remote tracking of aerosol clouds would have a major positive impact on situational awareness of the battlefield environment and associated effects on military operations. The Army needs to exploit this capability in its initiatives for the objective force visualization of “Current Weather Forward” and for real time joint intelligence through Horizontal Fusion.

Airborne Doppler lidar measurements of atmospheric boundary layer winds and aerosol spatial distributions are now a reality. A Navy-sponsored effort has put an eye-safe coherent system (200 KHz pulse rate) with ~ 6 km range at ~70 m range resolution on a Twin Otter aircraft.(Ref 1,2) The beam can be directed upward or downward and conically scanned to give high-resolution vertical profiles of horizontal winds at approximately 500 m intervals along the flight path; horizontal and vertical structure of aerosol distributions over a ground distance approximately equal to the aircraft altitude. Such data help identify aerosol plumes and obscurations and the wind field driving them. Utilization of this capability can provide a significant positive impact on the Army’s ability to describe in real time, the current state of the atmosphere at an unprecedented space and time resolution.
Research on weather model predictions of transport and diffusion of airborne materials show large errors of wind speed and direction near the ground and aloft. (Ref 3) Such errors cause significant uncertainty of predictions of downwind hazard areas. Aircraft-based measurements of real-time winds will significantly reduce the errors in hazard area predictions. To take this capability from research "toy" to high-valued information source, research is needed to develop analyses techniques and software to acquire and fuse airborne Doppler lidar data and products quickly and accurately into other battlefield weather information from multiple sources and scales. These data products will include: mean wind profiles; spatial distributions of winds across the battlefield or in data denied areas; spatial distributions of aerosol backscatter, and perturbations within those fields. (See reference material below.) In the future, smaller, lighter, more capable lidar systems will be developed for mounting on UAV or other air vehicles. Scientists at Army Research Laboratory are working with fusing remotely sensed atmospheric data into battlefield weather awareness, and tactical decision aids.

PHASE I: Research is needed to develop techniques to rapidly incorporate airborne Doppler lidar measurements into existing and developing atmospheric data assimilation and analysis techniques used by the Army. This effort will develop techniques to use airborne Doppler lidar measurements to utilize the data to their maximum efficiency to describe the sensed environment. Tasks within this phase should include:
a) Develop data analysis software to take aircraft mounted lidar data on backscattered energy and Doppler shift to provide a real-time display of wind speed and direction and aerosol backscatter as a function of ground position, time, and altitude above ground as well as the height of the atmospheric boundary layer. The system should provide for realistic scanning strategies such as: different scan rates, scanning plans and time of day. Particular emphasis should be given to the computation time; the space-time averaging of the product fields; their adaptability to simple and complex terrain; and their adaptability to existing or developing Army weather analysis systems.
b) Use real or realistic synthetic data to demonstrate the proof of concept of the technique.
c) Develop a plan to conduct field tests and objectively evaluate the improvement to existing analyses.

PHASE II: In this phase the contractor will perform three tasks. First, at least three in-flight data collection studies will be conducted at mutually-selected training or testing areas to test the display software and to demonstrate that the system works as designed. The tests may also support training exercises in which the added capability is available to one side and not the other. Secondly, the contractor will integrate the techniques into appropriate Army weather analysis and display programs working with Army scientists. The third task will be to assess the improvement to the currently available analyses by comparisons to unassisted measurements of variables such as boundary layer height; spatial sized of hazardous wind conditions; smoke plume transport and diffusion, and terrain effects on wind fields. When appropriate, Army personnel will be requested to assess the merit, utility, and quality of the product based on their operational experience.

PHASE III: Emergency responders and homeland security units need real time, high resolution wind information through the depth of the atmospheric boundary layer to assess the local transport and diffusion of toxins in order to assess effects and appropriately warn affected people. Such capability exists for only a few specialized fixed locations, but none with mobile capability. Mobile capability extends potential for real-time information on hazard areas, especially if there is aerosol component to the incident. This phase of the program will extend the capability from military to civil and commercial homeland defense applications.

REFERENCES:
1) Twin Otter Doppler Wind Lidar (TODWL) Publications: Available at: http://www.swa.todwl/publications.asp

KEYWORDS: Airborne Doppler lidar, Data Fusion, Battlefield winds, aerosol layers, Chemical/Biological agent transport
TITLE: Bistable Lattice Composites for Armor

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To design bistable lattice composites with superior structural resistance to impact.

DESCRIPTION: Technical Challenge/Background: High-performance armor and, more generally, materials for protection of personnel and platforms from impact/explosion, dissipate the energy of a collision/explosion by wave propagation and partial damage while keeping their structural integrity. The armor should excite controllable, energy-absorbent, high-frequency waves and should distribute partially damaged elements over a large area in as even a manner as possible. Armor with “waiting elements” possesses these features [1]. “Waiting elements” are elements in the lattice that are longer or shorter than the “main” elements and that become active only after significant compression or extension has taken place in the main elements. A lattice with waiting elements is characterized by bistability, that is, the existence of a second and stronger stable region in the dependence of strain on force. The non-monotonic dependence of the damage on the force leads to the greater than expected energy dissipation. Armor that includes waiting elements exhibits large pseudo-plastic deformations and intensive waves [2]. In such armor, multiple and widespread partial breakage absorbs some of the energy of the impact and numerous wave packets spread the rest of the energy throughout the impacted structure.

PHASE I: Determine one or more nontrivial classes of 2D lattice composite materials that include bistable/waiting elements and that can be used to design armor with improved performance under ballistic impact. Investigate and model the propagation of partial damage waves through these structures with specific armor materials (for example, metal-matrix ceramic composites). Investigate theoretically and/or computationally how the performance depends on geometric parameters and materials and on the impact (speed and mass of the projectile, characteristics of impact). Also, identify limitations on applicability. Quantify the advantages vs. existing armor materials. Specify and quantify disadvantages and limitations, for example, poor performance if a given range of angles of impact is exceeded. At the end of Phase I, present an assessment of feasibility and performance that includes: 1) justified statement of class(es) of 2D candidate materials, 2) expected range of performance gain in 2D, 3) disadvantages or limitations, and 4) description of 3D lattice composite materials that are candidates for exhibiting superior properties like those of the 2D materials.

PHASE II: Determine one or more nontrivial classes of 3D lattice structures that include bistable/waiting elements and that can be used to design armor with improved performance under ballistic impact. Characterize in detail the performance of the materials in these classes computationally. Optimize (either by hand or using the analysis software in an “outer loop” that minimizes some objective functional) the geometric design and materials. Design and fabricate one or more physical prototypes of armor. Investigate experimentally how these prototypes sustain impact and show that experimental results coincide with computational results. Quantify the advantages vs. existing armor materials. Specify and quantify disadvantages and limitations. At the end of Phase II, present: 1) one or more physical prototypes of 3D bistable lattice composite materials, 2) a full description of the behavior under ballistic impact of these prototypes, 3) comparison of the behavior of these prototypes with that of existing armor materials, and 4) cost comparison of the 3D prototypes vs. existing high-performance armor materials assuming large-scale production.

PHASE III: Design improved or optimal armor and/or protective structures and market these items for military and civilian applications, potentially including military armor, materials used in countermine operations, civilian vehicle safety devices, containers for transporting toxic or dangerous materials, covers of shelters and airplane baggage containers, etc.

REFERENCES:
KEYWORDS: ZnO Based Light Emitters for UV/Blue Applications

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Develop blue/UV light emitters (LEDs and semiconductor lasers) based on epitaxial ZnO semiconductors for a variety of DoD/civilian applications including solid-state lighting, chemical sensing, optical data storage, and displays.

DESCRIPTION: The ZnO semiconductor presents opportunities to develop new blue/UV lasers and light emitters which could surpass the performance of currently available LEDs and lasers based on GaN. The bandgap of ZnO is 3.4 eV (365 nm) and can be grown with high crystalline quality. Several other advantages of ZnO include: low growth temperatures and ability to alloy over large bandgap range: in blue/UV with Cd (CdO – 2.4 eV) and Mg (MgO – 7.8 eV). Another advantage is its high exciton binding energy of 60 meV make it possible to have exciton mediated carrier recombination dominant at room temperature. This will enhance gain and efficiency of recombination. Advances in p-type doping ability [1] and availability of lattice matched substrates [2], are indications that p-n junction LEDs are ready to be attempted. From the Army’s perspective, such high performance LEDs and lasers are useful for applications listed above as well as covert optical communications. These programs (GaN based emitters) are being funded at DARPA (SUVOS program) as well as other agencies. Thus, the development of ZnO LED’s and lasers presents an alternative to the large DoD investment in III-Nitride LEDs and lasers which is still underway.

PHASE I: Demonstrate strong photoluminescence and p-type doping of ZnO semiconductor and grow homojunction LED.

PHASE II: Develop p-n junction LEDs and lasers based on ZnO materials at and around 3.4 eV. Develop alloys and heterojunction LEDs using Mg, Cd ternary semiconductors for emission in the blue (~400nm) and UV (< 300nm) regime.

PHASE III DUAL USE APPLICATIONS: Manufacture blue and UV LEDs and Lasers (possibly white light LEDs) for application to several defense and civilian industries. Military applications include covert (non-line-of-sight) optical communications and chemical agent detection. Civilian applications include solid-state lighting and optical data storage. Another area of large impact is displays.

REFERENCES:

KEYWORDS: ZnO, Blue LEDs, UV LEDs, blue semiconductor lasers, UV semiconductor lasers

A04-069 TITLE: Compact Alkaline Fuel Cell System

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM Soldier Systems

OBJECTIVE: Design, construct, and evaluate a compact 20-W fuel cell system that: 1) utilizes an alkaline fuel cell, and 2) includes all balance of plant auxiliaries, such as fluid moving equipment, heat exchangers, and fuel storage vessel. The fuel cell power system should be compact and energy dense (> 1kWh/kg) while supplying 1.4 kWh of energy without recharging fuel. The power system should sustain two weeks of 20-W power production.
without electrolyte maintenance, with provision made to recharge unit with fresh electrolyte for restoration to original performance, if necessary.

DESCRIPTION: The Army has need for high-energy density, lightweight power sources for the soldier; for example, one potential scenario would require 20 W (electric) for a three-day mission. Hydrogen-air proton exchange membrane fuel cells (PEM FCs) are candidates to fill this need, but the hydrogen source is problematical. Liquid fuels (e.g., hydrocarbons or ammonia) may be transformed to hydrogen, but the necessary chemical processing steps add complexity, weight, and volume to the overall power system. Direct electrochemical oxidation of the fuel is a desirable alternative, but electrode reaction kinetics in the acid PEM environment are slow using even the most favorable liquid fuel, methanol. It is known, however, that electrooxidation reactions are relatively more facile in basic media, as well as the oxygen electroreduction reaction. Alkaline fuel cell (AFC) technology has been described as a viable alternative to PEM systems for transportation applications (1,2) but it has not been systematically explored for portable power applications. A recent assessment based upon published information of ambient-air PEM and AFC technologies at the 7 kW level concludes that the two power technologies are of similar cost (3). It is undetermined, however, if AFC technology can be implemented in a compact low-power (20 W) system that has sufficient resilience to carbonate build-up (e.g., 4) inherent in alkaline electrolyte exposed to carbon dioxide from air at the cathode or from deep oxidation of carbon-containing fuel at the anode. The performance of an AFC diminishes as carbonate content in the electrolyte increases and, if left unchecked, effects an unacceptable decrease in power production. The potential exists in a soldier power application, however, to replenish spent alkaline electrolyte on a maintenance schedule and thereby sustain acceptable power levels.

PHASE I: Design, construct, and characterize an air-fed, ambient pressure, multi-cell, alkaline fuel cell stack at nominal 5-W level using contractor’s choice of fuel other than hydrogen (but selected within bounds of safety and cost considerations). Report stack polarization behavior (voltage and power density as a function of current density); measure fuel utilization; determine and correlate stack performance with carbonate content in AFC electrolyte; discuss stack scale-up issues to 20-W (system) level; and discuss 20-W AFC system concepts.

PHASE II: Design, construct, and evaluate a 20-W alkaline fuel cell system. The system should be compact and energy dense (> 1kWh/kg) while supplying 20-W continuous for a three-day mission. Determine means to sustain 20-W level for two weeks of continuous run time without electrolyte replenishment. Deliver complete 20-W system to ARL for test and evaluation.

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

REFERENCES:

KEYWORDS: Alkaline fuel cell, fuel cell, compact power, soldier power

A04-070 TITLE: Innovative Standoff Sensor Technology for Military Robotics Platforms

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: JPM Guardian

OBJECTIVE: To develop a compact Laser Induced Breakdown Spectroscopy (LIBS) sensor with innovative components for optimal standoff performance. The sensor should be capable of standoff detection of 100 meters.
minimum and be suitable for mounting on Future Combat System (FCS) robotics military platforms such as the Armed Robotic Vehicle (ARV) and Multifunctional Utility/Logistic Platform (MULE).

DESCRIPTION: There have been a number of recent advances in LIBS sensor technology in both instrumentation and in applications. The recently developed broadband multi-spectrometer offers very wide spectral coverage (200-980 nm) in a rugged and compact package. Using this spectrometer, researchers have been able to detect explosives as well as chemical warfare agent simulants and biological warfare agent surrogates (bacilli spores, molds, etc.) in real-time. Such broad spectral coverage expands greatly the areas of LIBS application since all chemical elements emit light somewhere within the 200-980 nm range. There have been recent reports of LIBS analyses with standoff distances of up to 100 meters. Launching a LIBS sensor on military robotics platforms such as the ARV or MULE is highly desirable. However, much innovative technology development needs to be made in order to maximize the performance of such a package. In particular, innovative developments in all three major subunits are desirable. These are: (1) the laser source, (2) the light delivery/capture optics, and (3) the spectrometer. Key issues are: (1) ruggedness, (2) compactness, (3) low weight, (4) high energy/power efficiency, and (5) affordability. New approaches to laser design are needed in order to achieve the excellent beam quality necessary to create a spark at long distances in an ultracompact package as well as to produce this laser radiation in the eye-safe region. The power supply needs to be improved for efficiency and size considerations. New optical engineering approaches are necessary for the delivery/collection optics to make them as rugged and small as possible. The detector arrays need to be much more sensitive to collect the weak microplasma radiation at a distance.

PHASE I: Phase I work will include: (1) a report concerning new technologies and approaches for standoff LIBS, including innovative laser, optics, and detector (multi-spectrometer or echelle), and (2) a goal of demonstrating a compact telescopic laser light delivery/collection optical system of novel design.

PHASE II: In this phase, a fully portable and rugged LIBS standoff sensor will be built, tested, and delivered to the Army for further testing. This innovative LIBS system will consist of an eye-safe short-pulse laser operating in the nanoseconds or shorter pulse duration region as well as the telescopic optics developed under Phase I which will allow for the capture of the full spectrum of 200-980 nm per laser shot with 0.1 nanometer spectral resolution or better. The laser, optics, and detector systems will be of a new design specifically tailored for standoff LIBS applications on the Army’s robotics platforms. In addition, the system will integrate video capability for targeting and tracking the LIBS spark. Consultation will take place with the LIBS research underway at the Army Research Laboratory at Aberdeen Proving Ground.

PHASE III DUAL USE APPLICATIONS: Design and development of a standoff LIBS sensor system will be beneficial to multiple industries such as oil, chemical, mining, etc. which have a need to monitor the presence of toxic chemicals at a distance in real-time.

REFERENCES:
4) See http://www.arl.army.mil/wmrd/LIBS

KEYWORDS: Standoff Chemical-Biological Real-Time Sensor, LIBS

A04-071 TITLE: Repair, Regeneration, and Differentiation in Humans

TECHNOLOGY AREAS: Human Systems
OBJECTIVE: To develop a model assay system for testing compounds and conditions that promote scarless tissue regeneration and wound healing.

DESCRIPTION: Although improvements in body armor have had a significant impact on reducing mortality in soldiers, ballistic damage to outer appendages such as arms and legs often results in loss of function or loss of the entire limb, leading to significant reductions in force capability, and an increased medical logistics burden. In addition, accidental exposure of unprotected soldiers to very loud noises results in hearing loss, making the individual unfit for duty and leading to involuntary discharge. At present the ability to restore appendages or organ function in humans is marginal. However, results from basic research in fish, frogs, salamanders, birds, mice, and bears indicate not only that regeneration of tissues and organ function is possible in mammals, but that the genetic, biochemical, and physiological regulatory networks are conserved across a wide range of genera. In addition, regeneration of small appendages such as finger tips and the ability to heal without scarring are well documented in human children, indicating that the genetic capacity for regeneration is present but turned off in adult humans. This strongly suggests that a genetic and biochemical understanding of how regeneration occurs would lead to the ability to activate the genetic and biochemical regulation cascade in human adults. In support of this is the very recent observation with mice that down regulation of the homeotic complex (HOX) family of transcriptions factors occurs during scarless wound healing.

Significant achievements in deciphering the molecular events in wound healing and repair have been described recently. Animal and in vitro models have been developed. Of particular interest is the MRL mouse that has the ability to heal complex tissue wounds. In vitro models, such as the fibroblast populated collagen lattice, the scratch technique, and aortic rings embedded gels, are being studied as well. Phase I of the research could start with one or more of these, or a new model that would be developed.

Identifying the molecular trigger could lead to the ability to: 1) grow inner ear hair cells and restore hearing in injured soldiers; 2) regrow lost appendages such as fingers, toes, arms, legs, and ears; 3) recover function in tissues damaged to biological agents such as gangrenous clostridia and streptococcal “flesh eating bacteria,” or diabetic ulcers, and 4) regenerate function in damaged organs such as the heart.

The principal deliverable from this study would be an assay system for testing compounds or conditions that promote tissue regeneration without scarring.

PHASE I: A genetically tractable and manipulatively amenable organism or in vitro system would be selected for developing an assay system for manipulating the genetic and biochemical signals eliciting regeneration in damaged tissues. With the selected system, a regeneration paradigm would be established that would be suitable for molecular analysis as well as chemical intercession. Phase I would establish proof of concept for the system, and demonstrate the ability of the model to be manipulated for studying wound healing and regeneration as described for Phase II.

PHASE II: Physical, genetic, and biochemical conditions requisite to establishing and maintaining regenerative competence would be determined. Genetic, genomic and proteomic analyses could be utilized to ascertain the essential molecular components for initiating regeneration as opposed to scar development. Areas of investigation could include, but not be limited to, cytokine alterations, activity of metalloproteinases, growth factor effects, etc. Chemical triggers in damaged tissue for regeneration would be pursued. Innovative early detection methods could be developed for potential use in whole animals as a metric of regeneration in damaged tissues following treatment. The main deliverable from Phase II would be an authenticated system for regeneration testing and analysis of the events that are essential for regeneration. In addition, a library of compounds that have potential as stimulators of regeneration would be selected and tested in the system.

PHASE III DUAL USE APPLICATIONS: The research to be developed under this SBIR would have military and civilian importance. There is already substantial commercial interest and activity in this field. The elicitors of regeneration would be tested and developed for field application. The generality of the response to the chemicals and the efficacy in different traumatic settings would be determined in collaboration with trauma centers and combat casualty units. Formulations of the eliciting compounds would be developed and tested. For example,
genetic or biochemical reprogramming of regenerative competence in damaged tissues toward reacquisition of normal function instead of massive scar deposition could minimize physical disfiguring and loss of function. Both the quality of life of the injured soldier and potential return to service could be greatly facilitated. Civilian applications could be made to tissue damages from accidents, infections, and physiological trauma. In addition, pathological aging phenomena in the nervous system could be retarded or reversed through neurite regeneration. In cooperation with bioengineers, scaffolding for bone and organ regeneration could be infiltrated with regenerative tissues for the traumatized structures. Potential civilian uses are widespread, including regeneration of appendages and organs damaged by accident or disease, including diabetes ulcers, heart disease, balding, and osteoporosis.

REFERENCES:
7) Sanchez Alvarado A, Neurath M A. 1998. The use of planarians to dissect the molecular basis of metazoan regeneration. Wound Repair Regen. 6, 413-20

KEYWORDS: Regenesis, regeneration

A04-072	TITLE: An Atmospheric Surface Layer Profiler

TECHNOLOGY AREAS: Ground/Sea Vehicles, Battlespace

OBJECTIVE: Develop a transportable, environmentally safe, surface based suite of instruments that will remotely measure wind and/or temperature from 10 meters to at least 100 meters above ground with performance comparable to existing in situ sonic anemometers or aspirated thermometers.

DESCRIPTION: Meteorological towers are the principal means of obtaining in situ measurements of near-ground turbulence and turbulent heat, mass, and momentum fluxes affecting the surface energy budget, which drives the lower atmosphere, and strongly affects the quality of weather forecasts and battlefield awareness at the operational scale of the Future Combat Systems. Weather forecast models unsuccessfully depict conditions at this scale (root mean square wind direction error of ~40+ degrees) and are notoriously poor in prediction of dispersion of airborne aerosols and gases, especially in the absence of observations. Much of that failure lies in the lack of routine measurements of the spatial and temporal variation in the lower 100 m of the atmosphere at and below the resolution of the model. Such measurements are a vital part of assessing the transport and diffusion of airborne toxins affecting military and civilian populations.

Major development programs are in place to replace the balloon-borne instrument packages (rawinsondes) which support Army artillery. Several technologies have been developed to measure winds and temperatures as a function of altitude above ground. Operational wind profiling radars do not currently measure winds below 75 to 100 m and only at five to ten minute averages of the components with >1.5 ms-1. The turbulent eddy profiler can measure all wind components at time scales of seconds but not below 50 to 100 m. Doppler sodars use acoustic rather than radio pulses to measure winds. Mini-sodars are effective from 10 meters to 250 meters with ~10 m resolution, however, the turbulence components are not measured and the acoustic noise can be a problem. Remote sensing of
temperature profiles has been accomplished using radio-acoustic sounding system (RASS) and passive multifrequency radiometric systems. Neither system can meet the temporal resolution and specifications of the sonic anemometers.

Recent developments in fiber optic and laser communications (See references below) have suggested that eye-safe, low power, compact systems may be adapted to make high frequency (~10 Hz) measurements of wind components in small volumes. Direct detection techniques have shown the potential to make temperature measurements and have been proposed for satellite-based wind profiling laser systems. A mobile or easily transportable facility with the above capability is highly desirable to provide local weather support and battlefield weather situational awareness. It also fills a critical need for onsite weather support to chemical/biological/radiological incidents and accidents. It is also very useful to conduct long term studies of the near-ground atmosphere in populated urban warfare areas at a much lower cost and greater flexibility than a network of fixed towers.

PHASE I: Prepare a proof-of-concept report using analytical and engineering studies to show that the design will meet the measurement objectives given above. Figures of merit should show that the device is capable of measuring either wind or temperature or both at ~10Hz sampling frequency in a small volume at approximately 10 meter increments to at least 100 meters. Potential non-performance due to environmental or technical circumstances should be identified and their frequency of occurrence estimated. A cost estimate for prototype is required.

PHASE II: This phase consists of three parts:
1. Construct a prototype system in accordance with the accepted design using off-the-shelf equipment insofar as feasible. Develop appropriate software to convert the measurement data to scientific or engineering units.
2. Develop an approved test plan to evaluate the system against an existing, well-calibrated meteorological tower. The plan should indicate the statistical tests planned, the period of testing and the anticipated conditions which the
3. Conduct the test in accordance with the plan.

PHASE III: The technology developed within this effort should have significant potential for commercialization in air quality studies by industry or governmental agencies. The technology could replace and improve existing meteorological towers at a lower operating cost. The instrumentation could become a very important part of research and development needs to improve atmospheric transport and diffusion models of chemical/biological materials at battlefield and urban scales (distances under 20 km) important to military operations, homeland defense, and air quality modeling and prediction. Improvements to current weather prediction models will require a low-cost measuring capability available with these “electronic meteorological towers”.

REFERENCES:

KEYWORDS: Chemical/Biological defense, atmospheric dispersion models, meteorological tower, remote sensing, atmospheric turbulence.

A04-073 TITLE: Visual Stoichiometry Breaking in Linear Response Chemical Test Strips

TECHNOLOGY AREAS: Biomedical, Sensors, Human Systems

OBJECTIVE: Utilizing the psychovisual characteristics of human vision, design and develop chemical test strips that, upon exposure, can be analyzed quickly and quantitatively by the human eye.

DESCRIPTION: Chemical test strips are used to provide fast analyses of gas and liquid samples for the presence of a target analyte. They are employed in the detection of a range of chemicals and contaminants, from metal ions in solution to hazardous vapors, to specialty aerosols and reagents. Exposure of these strips results in a color change
indicating presence and concentration of the target molecule. The resulting color change is often compared with a reference standard to obtain an estimate of the concentration of the analyte. Even test strips with discrete readout steps require this comparison. Some color strip systems can be used in conjunction with a dedicated instrument to obtain a more precise evaluation of the concentration. In these circumstances, the use of comparitors and instruments is often required because the dose response curves for these test strips are linear with a concomitant linear evolution of color. The human eye does not detect small linear changes in optical density with precision. Changes of less than 10% in OD are not discernible even in hues where the eye is most sensitive.

Although the exposure of the test strip is straightforward in deployment and evolution of the signal proceeds without user intervention, the readout of the result requires time and/or training to yield a value for the concentration of the analyte or of the significance of the concentration. In applications of test strips where time and action are significant, as in events where hazardous materials are being evaluated in a quick reaction situation, the readout of the test strip response must be fast reliable, and unambiguous in an interpretation to the human eye. The certainty in interpretation will also allow personnel with less training utilize these devices with confidence. What is required is a visual readout system that is designed with the human eye as the analytical device. It is well known that human vision perceives not only with intensity and position, but also spatial frequency, contrast, luminance, among others. What is most valuable to the user in a fast response situation, is a step function response of the test strip that provides distinct changes in the readout that the human eye can perceive with clarity and certainty, without resource to comparitors or instruments. This capability is of highest importance near the lowest level detectable concentration ranges. In many cases, this extends to the ppb and tens of ppb level.

PHASE I: Using knowledge of the psychophysics of human vision, design a theoretical system for a readout from a chemical test strip that transforms the linear color response of the strip to a putative analyte into a step function change in perception of change in the strip by the human eye. Implement this model for the readout with the assembly of a linear chemical test strip for an analyte of importance in the solution or vapor phase. Show that a linear response of the strip to analyte presence can be perceived by the human eye as one or more step function changes in the readout signal.

PHASE II: Extend the capability of this readout technology to utilize the human visual perception of spatial frequency modulation, luminance, and contrast to improve and optimize the optical density range over which the step function in perception occurs. Given target analytes of importance, utilize this readout technology in real chemical test strips for both vapor and liquid samples to provide step function appearances of analyte concentration values, symbols, or messages of importance to the user.

PHASE III DUAL USE APPLICATIONS: This technology has a general use in all applications in the domestic market in which chemical test strips may be employed, in either a gas phase or solution phase analysis of chemical content and contamination. Such markets include public health and safety as well as environmental tests for hazardous materials in soil and water.

REFERENCES:

KEYWORDS: Psychophysics, test strips, dose-response

A04-074 TITLE: Intelligent Force Management

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The Army has numerous diverse, geographically distributed organizations/units that recruit personnel, train them, assign them to appropriate tasks, deploy them to serve on various missions, and track their
performance (both in terms of how well they are doing their job, as well as in terms of health, morale, etc.). A lot of this personnel data is managed at a local (organization/unit) level. Hence, it is difficult for higher-level Army commanders to find out when, and which troops/units are mission-capable, for any selected mission; specifically the state of readiness of any given units/troops is not clear, or readily obvious. Therefore, as an approach to addressing this problem, the Army leadership is interested in state-based modeling techniques that enable the tracking and assessment of the "state" of Army personnel and their units (current level of training, current health, etc.). New technologies are required to provide significant enhancements/capabilities to current Army processes/systems; when implemented these technologies are expected to result in better-informed decision capabilities, in the context of an analysis of all possible alternative actions (such as personnel/unit deployment, force composition, etc.).

At present, the Army is at work with the Strategic Readiness System (SRS); this is an evolving conceptual system that uses numerical-objective functions to describe various desired states of the entities (units/troops) comprising the system. For example, if a decision pertains to composing a force for a given mission, the objective function helps determine the relative merits of different staffing alternatives.

While SRS is in early use today, the present capability does not meet the above stated requirements. One of the most significant current limitations is the lack of the capability to predict the ramifications of a given decision and facilitate a comparison of alternatives. Currently, the SRS effort is limited to combining independently derived predictive modeling efforts, from various Army functional/specialty domains and processes. When a change is mandated, or a "what if" analysis by executive decision-makers requires analysis of alternative solutions (or courses of actions), each model is rerun independently based on the changed parameters and constraints. These independent runs are then analyzed, and the data is manually evaluated to estimate the impact of the alternative decision(s).

DESCRIPTION: To address the challenge of providing a more semi-automated and integrated solution for enhanced decision-support capabilities, it is proposed to augment the existing SRS effort with an SBIR project, focused on the development of an "Intelligent Force Management Agent Architecture". The Research and Development objectives of this SBIR are expected to provide dynamic semi-automated predictive readiness analysis, and help document the likely consequence of various alternative actions. Changes in the metric and measurement values (numerical-objective functions), the elements that comprise the "scorecard" for an organization, should enable evaluation of "cause and effect" for each of the possible alternative-decisions effected by the changes. Desired future consequences, compared to the expected ramifications of any of the alternative decisions will help identify possible risks; specifically of interest are those risks related to the need of providing timely actions and necessary resources needed to insure any desired objectives.

The Army SRS Automation Team will work closely with the selected SBIR contractor. Further, the SRS team will support the effort with any required hardware and software to help insure a successful effort. Additionally, the SRS team provide the required subject-matter experts in the functional/specialty domains required for an implementation of an advanced SRS system.

The deliverable is expected to be a component-based software agent system. The system to be delivered must support a multiple number of dynamic parameter and constraint inputs (numerical objective functions); these functions will be used to enable selected predictive unit/organizational modeling capabilities. Once the various relevant units/organizations have completed their modeling runs, and provided a predictive output, the agent-based implementation will provide rule based inference capability; this will allow the integration of the various numerical objective functions, leading to the semi-automated derivation of an overall assessment of alternative decisions/actions. Specifically, the agent based system, to be provided, will help insure that a correct measure of the merits/risks of any given decision/action is provided to the SRS. Agent technology is well described in [1,2,3,4,5,6].

PHASE I: Develop a model for objective-function based force management that can support agent based decision making over multiple heterogeneous data sets containing personnel, logistics and or unit/installation data. At present there is no principled unified mechanism for integrating data, synthesizing information, and/or succinctly eliciting application/user relevant information from a multiplicity of possibly distributed, heterogeneous, and multi-modal/media data resources. A major limiting issue, has been the lack of technology-support for dealing with the "semantics" of the data. This SBIR research is intended to focus on the problem of data integration in a semantically
correct way, and enable the automatic triggering of appropriate data transformations, presentations, integrations, and the automatic generation of other relevant data-oriented actions (necessary to facilitate the derivation/presentation of salient application/user information). Establishing semantic relationships between multiple terms in data resources is a difficult linguistic problem. Additionally, military applications are replete with military-specific terms, and abbreviations that are not found in common dictionaries, making the proposed application an excellent demonstration candidate for this research. This SBIR research is expected to provide methods for answering queries, taking the semantics of the data-resources onto account and address the relationships of the data entities. It appears that principled "agent-oriented" technologies offer potential solution to the issues addressed above; hence the emphasis of the SBIR research should include the need to rapidly construct and customize any agents that are needed for a given application. PHASE I should result in the basis for the construction of a prototype component-based software agent system (and the principled means for the rapid construction and customization of application agents) based on the underlying fundamental principles/methodologies developed in this SBIR effort.

PHASE II: Develop a prototype system that implements the models/metodologies developed in PHASE I, and demonstrates how this system works on two selected Army data sets that currently support SRS.

PHASE III: Develop methods to scale the prototype system developed in Phase II to handle large numbers of concurrent requests, as well as at least five to ten data sources. In addition to completing the transition of any theoretical/technology advances to the SRS systems implementation, it is expected that the SBIR contractor seek to commercialize the SBIR research/development products. The government and civilian sector offer numerous data-driven applications for the expected technologies that will enabled by this SBIR. Virtually any decision-support, and/or situation-monitoring application is a likely candidate for application of this SBIR work. Specifically, the SBIR contractor should identify at least one commercial application that will be addressed in PHASE III. Commercialization of the technologies enabled via successful PHASE I/PHASE II efforts should reflect product development that is marketable for applications that include those related to corporate information management systems, web-based information search, medical information systems (records, patient care, etc.), system/software engineering, and law enforcement. The SBIR contractor should indentify a commercialization area of choice and present a marketing plan to support their commercialization effort.

REFERENCES:

KEYWORDS: Decision-Support, heterogeneous data-management, data-fusion, inferencing for interpretation, machine-reasoning, intelligent software agents, information-fusion, and probabilistic predictions

A04-075 TITLE: Unmanned Aerial Vehicle (UAV) Close-Formation Control System (CFCS)

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation
OBJECTIVE: To develop an instrumentation/control system that will enable an Unmanned Aerial Vehicle (UAV) (fixed or/and rotary wing) to fly in close formation with a manned aircraft.

DESCRIPTION: Airborne icing trials play a key role in the aircraft qualification/certification process. The US Army Aviation Technical Test Center currently uses the CH-47D Helicopter Icing Spray System (HISS) to conduct artificial icing test on fixed wing and rotary wing aircraft. The HISS is a unique national test asset with the ability to perform low airspeed/low altitude icing trials for rotary wing and turbo-prop airplanes, and potentially for UAV platforms as well. The HISS generates an artificial, customized cloud with controlled & quantifiable characteristics for the accretion of various ice forms on a trailing test article (in trail flight formation). The current HISS, however, does not have the capability to be used in UAV icing tests due to the unresolved technical problems associated with flying a UAV in close formation to a manned platform. The testing tolerances (X,Y,Z positioning criteria for the UAV) are extremely tight and demanding. Without the artificial testing capability provided by the HISS, icing trials would have to rely totally on naturally occurring clouds (uncontrolled conditions) as the only method to qualify UAVs. Chasing natural icing conditions needed for system qualification/certification results in longer test programs with corresponding increases in cost and schedule delays. Also, with natural icing there is an increased safety risk due to flying unproven systems in adverse weather conditions under instrument conditions. Artificial icing provides safer Visual Meteorological Conditions (VMC) for the aircrew with the ability to rapidly exit icing conditions. In order to perform artificial icing test on UAVS, a manned aircraft to UAV control system interface must be developed. This is an inherently risky technical challenge.

The desired solution is an instrumentation/control system that will allow a UAV to fly in close formation behind a manned aircraft (i.e., the CH-47 Chinook HISS). Maintaining a closed control loop between the UAV and the aircraft is critical to test performance and safety criteria. The system must be able to accurately locate the UAV relative to the manned aircraft as a function of time in order to maintain the required spatial relationship between the manned aircraft and the UAV during all phases of the mission flight scenario.

Critical areas in the UAV to manned aircraft interface system include: entering the required trail formation (behind and below the HISS), maintaining test formation, and exiting test formation. The system developed must enable the UAV to safely enter into formation behind the manned aircraft and fly at an assigned mission altitude of up to 10,000 ft. The system must allow the UAV to maintain a separation distance from the manned aircraft of 120 ft with a threshold tolerance of ±20 ft (±10 ft desired). The system must allow the UAV to maintain a constant altitude relative to the manned aircraft during the test within ±10 ft (±5 ft desired). The system must allow the UAV minimize lateral drift to within ±10 ft (±5 ft desired). The system must be able to accommodate UAV airspeeds between 70 knots and 130 knots and mission durations of 45 to 60 minutes.

The desired system must be able to support both fixed wing and rotary wing UAVs with minimal UAV air platform integration required. An appliqué solution would be preferable to an involved integration effort. The system must enable the UAV to respond to command signals from the operator or manned aircraft which will indicate test completion and that the formation flight should be terminated. Also, in an emergency situation, the system must allow the UAV to respond by rapidly exiting the test formation and to fly away from the manned aircraft in a safe and expedient manner.

PHASE I: The contractor shall research available and emerging technologies and methods for supporting the required capability of a UAV flying in close formation with a manned aircraft. A major portion of the research and investigation should be directed at methods for the manned aircraft and UAV to safely enter, maintain, and exit a trail flight formation (UAV below and behind a manned platform). A concept review will be held that will outline the feasibility of such a system, and an overall design proposal with materials, software, electronics, and operational procedures. A detailed trade study will be part of the concept review.

PHASE II: The contractor shall build and deliver a prototype of the instrumentation/control system using the technology selected in the Phase I effort for government integration and testing in conjunction with the HISS.

PHASE III: The contractor will transition the instrumentation/control system technology utilized for HISS-related UAV applications to a highly versatile UAV instrumentation and control capability, using the validated design and working prototype from Phase II. The contractor will transition the technology to a production capable item.
contractor is expected to expand the Phase II technology development to other UAV applications, such as UAV airborne air-to-air refueling and UCAV/UCAR attack UAV missions that use swarm or formation flying. Commercial applications may well exist for long endurance/loiter missions for UAV such as cell phone/communications relay.

REFERENCES:
3) Melgrad, Last, and Thomas, Precise GPS time transfer to a moving vehicle, September 1995.

KEYWORDS: Unmanned Aerial Vehicle (UAV), formation flight, artificial icing, Helicopter Icing Spray System (HISS), closed-loop control feedback, station keeping, Unmanned Combat Armed Rotorcraft (UCAR)

A04-076 TITLE: Chemical Cloud Tracking Through Hyperspectral Imaging

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: Develop a system to detect and track chemical clouds designed to referee testing for chemical/biological contamination avoidance that makes use of hyperspectral imaging technology.

DESCRIPTION: Infrared (IR) cameras are limited in their capabilities to quantify chemical clouds owing to their low spectral resolution. They are good at defining the location of a high concentration cloud, but lack in specificity, quantitation of cloud concentration, and sensitivity to low concentration. Passive Fourier transform infrared (FTIR) spectrometers, on the other hand, are limited in their ability to characterize a cloud spatially because they are essentially "single pixel" devices. Scanning FTIRs can partially resolve this issue, but they are limited temporally. Hyperspectral imagers have the ability to resolve both spectral and spatial data and would be an ideal solution except that they are costly. Several strategies for developing a lower cost hyperspectral imager are possible and this SBIR will examine these.

PHASE I: A feasibility study will be conducted to produce a relatively low cost hyperspectral imager. Tradeoffs between cost, risk, spectral resolution, and spatial resolution will be examined. A solution will be proposed and a cost estimate provided. The feasibility of developing a prototype in Phase II will be specifically addressed. The study should include a proposal for data management, including addressing the possibility of data compression, storage media, data archival and retrieval, and reduced data products that can be transferred to end-users.

PHASE II: A prototype hyperspectral imager will be produced. It will include software to detect and track simulant clouds commonly used at Dugway including triethyl phosphate, acetic acid, and sulfur hexafluoride. It will also include the ability to display useful subsets of the data in false-color movies or the changing spectrum of a single pixel in time; and the ability to deliver reduced-data products to the end-user. The ability to easily update the list of simulants shall be included. The software will be developed to include the possibility of adding one or more additional hyperspectral imagers and to reconstruct a three dimensional cloud. A demonstration software module that simulates the data to be produced from additional hyperspectral imagers will be presented. A demonstration of the prototype itself will be conducted at DPG.

PHASE III: There are a myriad of commercial uses of hyperspectral imaging systems. They can be used for plume-tracking, pollution control, or for commercial protection against terrorism. Additionally, non-chemical uses involving the identification of objects exist. The principal barriers to commercialization are cost and time to produce a system. Strategies to reduce the cost and time to produce a hyperspectral imager will be pursued. Although, true mass production is unlikely to be possible at this stage, the ability to produce hyperspectral imagers with a short lead-time to meet customer needs should be developed. Long lead-time parts should be produced in quantities that allow the developer to be responsive to customers. Market research should be conducted in order to
determine whether other functionalities should be added to meet the needs of potential customers outside of the army. Additionally a full system will be developed to merge the data from multiple imagers at different grid coordinates. A working prototype should be delivered to Dugway Proving Ground for Army Test and Evaluation

REFERENCES:
4) Bandara, Gunapala, Liu, Rafol, Mumolo, and Reininger, Large Format, 6-10 and 10-15 Micron Dual Broad-Band QWIP Focal Plane Array.

KEYWORDS: Infrared spectroscopy, chemical warfare agent detection, hyperspectral imager, radiometer, infrared camera, multispectral imaging, cloud tracking, referee systems, pollution, plume tracking

A04-077 TITLE: Prognostic Wear Prediction Tool for BlackHawk Hanger Bearings

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PM, Utility Helicopter

OBJECTIVE: The objective of this topic is to develop an advanced bearing wear prediction model-tool, which has the capability of integrating real world Health and Usage Monitoring System (HUMS) vibration data (Blackhawk HUMS Demonstration) for the Blackhawk tail-rotor shaft hanger bearing.

DESCRIPTION: The Black Hawk tail drive shaft is supported by three hanger bearings. The hanger bearings include a concentric bearing unit and damping unit. The bearing unit is mounted on the shaft and the damping unit (an oil filled poly-urethane bladder) is mounted inside the tail boom attachment fixture. The bearing is shielded and permanently greased. The current maintenance procedure includes periodic visual inspections and replacement of the hanger bearings at fixed intervals. A dominant failure mode is that as a result of wear or loss of lubrication the bearing heats up, eventually softening and tearing the polyurethane bladder. That results in loss of controlled radial support (at least to the extent of motion permitted by the outer structure of the support fitting). This typically results in high vibration and if unchecked can lead to tail drive failure.

The Army is currently conducting a demonstration of HUMS equipment on several Army UH-60L aircraft. Goodrich Corporation manufactures the HUMS. The HUMS Open System Specification provides details on available data and interfaces.

The intent of this topic is to: 1) Develop a prognostic tool which can accurately characterize the wear mechanisms of a component, in this case a Blackhawk tail-rotor drive shaft hanger bearing, 2) Allow for incorporation of HUMS data from current Blackhawk HUMS Demonstration program; and 3) Allow for, if desired, other data input parameters which the contractor deems relevant towards developing its prognostic tool (e.g., flight regimes, temperature, torque, etc). In order to perform bearing prognostics it may be necessary to couple physics based models with bearing condition interrogation sensors (e.g., vibration, temperature, torque). Accurate prognostic models would have to take into account maintenance actions and environmental conditions (e.g., desert, arctic, heat-humidity) that may interfere with lubrication, hence wear dynamics. The key to successful bearing prognostics is establishing models that correctly establish initiation of bearing faults (spalling, pitting, etc.) and accurately model fault progression. The contractor must be able to validate its developed wear model. The Program Plan for the Phase I needs to be carefully planned, such that the Phase I results shall be sufficient for the Government to award the bridge option and a Phase II effort.
PHASE I: The objective of Phase I is to develop an advanced bearing wear prediction model-tool, which has the capability of integrating vibration data and other parameter inputs. The contractor may propose additional sensors to acquire necessary data for the tool. Reference the Goodrich HUMS Open System Specification for details on available sensor data. A clear means of validating any results, derived from this effort, is a minimum requirement.

PHASE II: The Phase II objectives are to further develop and demonstrate the prognostic wear prediction tool by incorporating vibration data acquired from the Army Blackhawk HUMS Demonstration program. During Phase II, it is desired to demonstrate the wear prediction tool by integrating it into the HUMS configuration.

PHASE III: The Phase III objectives are to validate, test, and qualify on an existing Army designated HUMS system; test the prognostic package on a test aircraft.

DUAL USE APPLICATIONS: The resulting technology will be applicable to both military and commercial aircraft, UAVs, automotive, trucking, and marine markets, as well as, any other market using rolling element bearings.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Various HUMS cost benefit analyses show a reduction in O&S costs and a return on investment at 1-3 years. An accurate on-board prognostic wear prediction tool is an enabling technology for maximizing the HUMS potential.

REFERENCES:

KEYWORDS: Prognostics, HUMS, Failure Prediction, Engines, Transmissions, RAM

A04-078 TITLE: Obstacle Display for Hover in Degraded Visual Environments

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: The objective of this topic is to develop an integrated system of human-interface devices that provide the rotorcraft pilot the three-dimensional spatial relationships between the aircraft, terrain, and obstacles. These pilot-interfaces are intended to be used during approach-to-landing, hover, landing, and take-off maneuvers. The challenging part of this effort is the human-engineering design of the pilot-interface content and methods. A large amount of information must interpreted by the pilot, within an acceptable amount of time, and within an acceptable amount of workload. The sensor will be simulated; design parameters for the sensor will be generated from the pilot-interface requirements.

DESCRIPTION: AH-64 helicopter accident data was evaluated since this aircraft has a display of the spatial relationship of the aircraft with respect to flat terrain on the hover symbology display, and has limited obstacle information in the infrared scene content. Despite the availability of this display in the cockpit, there were still a substantial number of accidents while hovering at night, when the hover display and infrared imagery should have been used. These accidents seem to fall into one or more of four categories:
1.) Intentional motion into terrain & obstacles which were not seen because the obstacle was out of the field-of-view of the infrared sensor (40 degrees) or the obstacle was too small to be seen with the sensor (wire & trees).
2.) Misjudged height or misjudged distance of obstacles/terrain during intentional aircraft motion.
3.) Misjudged aircraft flight path (horizontal or vertical) during intentional aircraft motion.
4.) Unintended horizontal or vertical drift into known terrain & obstacles; hover display was probably not attended to.

Adding 360-degrees of terrain/obstacle distance and height information to the hover symbology should be an improvement to the current 40-degree field-of-view terrain/obstacle information currently available through the
infrared imagery (addressing the first three accident categories above, and assuming a high resolution sensor can be found). However, a visual display by itself may be insufficient because the pilot may be attending to another focal-vision task, and not be able to attend to the hover display. Non-visual pilot interfaces such as tactile belts/vests and audio signals may require little pilot attention (addressing the fourth accident category above), but have traditionally not had the resolution and/or usable bandwidth required for precise low speed and hover flight control around obstacles. The best of both worlds is possible; non-visual, low attention interfaces can provide information on the general horizontal and vertical direction of approaching terrain and obstacles, while visual, high attention displays can provide precision. When unexpected motion or unexpected obstacles are sensed by the pilot through non-visual interfaces, the pilot's attention can switch to the visual display. The solution appears to be an integrated system of sensors, computer, visual displays, and non-visual pilot interfaces. The content and methods of providing the pilot the required information is not clear, and is the main focus of this topic.

PHASE I: Based on sound human-engineering principles, and leveraging previous work in this area, develop pilot-interface design concepts that meet the objective and description of this topic. For the visual display portion of the system, document the pilot-interface concepts with animations or story-board drawings that include approach-to-landing, hover, landing, and take-off maneuvers. Use the animations/drawings to collect structured, subjective pilot comments on the usefulness and potential problems of using the display. Collect structured pilot comments on the most desired methods of providing non-visual interfaces. Use a scenario of poor weather and night civil Emergency Medical Service (EMS) helicopter tasks. Also use a scenario of Army clear-weather night operations. Use current or former civil EMS pilots and Army AH-64 pilots. Assume both panel-mounted and head-mounted displays in the animation or storyboard. Deliver a Phase I report detailing the pilot-interface concepts and the results of the structured interviews.

PHASE II: Design, fabricate, and deliver a rotorcraft simulation system with the pilot-interfaces that provide the spatial relationship of the aircraft with respect to the terrain and obstacles, as described in this topic. The system needs to include visual and non-visual pilot-interfaces to inform the pilot of motion toward terrain/obstacles. Using the simulator, conduct a formal, human-subject study of pilot performance and workload using current or former civil EMS helicopter pilots and military rotorcraft pilots. Use standard civil EMS and Army procedures for the approach-to-landing, hover, landing, and take-off maneuvers in the study. In the study, simulate a sensor than can provide the 3D relationship of the terrain and obstacles with respect to the aircraft. Also determine the basic required sensor parameters, such as field-of-view, field-of-regard, range, resolution, and scan rate. Determine these sensor parameters both with and without a persistent, continuously updated, 3D database of terrain and obstacles. Deliver a phase II report documenting the system design, the test procedures, and test results.

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

OPERATING AND SUPPORT COST REDUCTION (OSCR): Reduce helicopter accidents. Increase the visual conditions in which helicopters may operate. Further enable uninhabited autonomous rotorcraft operations in obstacle rich environments and poor visibility conditions.

REFERENCES

KEYWORDS: helicopter, rotorcraft, hover, obstacle, display, brown-out, pilot interface

A04-079  TITLE: Electromechanical Actuator Controller Technology

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Apache

OBJECTIVE: Design a digital controller for electromechanical flight control actuators for small unmanned aerial systems (UAS) (1500lbs GW) and manned utility rotorcraft. The objective is to reduce the size and weight, currently dictated by heat rejection and electromagnetic interference (EMI) criteria, of existing electromechanical actuator controllers. This objective supports the goal to replace hydro-mechanical actuation systems in rotorcraft with non-proprietary electromechanical systems. AATD is interested in commercial and military electromechanical actuator controller products or components/systems that are suitable for, or readily adaptable to, rotorcraft applications but may require further development.

DESCRIPTION: UAS typically use electromechanical actuation (EMA) instead of hydraulic actuation for flight control. Recent development efforts by the Rotorcraft Industry Technology Association (RITA), Inc. and others, have provided data that demonstrates that EMA systems are lighter, less expensive (in acquisition and direct
operating costs) than centralized hydraulic systems. Since UAS may require long term storage before use, there is a concern for seal deterioration and ensuing leakage associated with hydraulic systems.

Current fly-by-wire controls are centralized. Actuator ram position commands and loop closures occur between the flight control computer and the actuator controller. This architecture requires several EMI resistant wires per channel. To minimize electrical resistances the controller has to be located as close as possible to the EMA. This requires high temperature electronics or exotic cooling schemes in regions of the vehicle where avionics cooling is not available. Locating most controller functions within the flight control computer may reduce weight, volume, heat, and EMI concerns associated with the current architectures.

PHASE I: The objective of Phase I is to define UAS flight control and vehicle management system requirements and develop a preliminary design for a digital electric/photonic actuator controller that meets these requirements. Assess the feasibility of designing and building a practical controller from this preliminary design. Identify technology barriers, potential reliability and cost issues. Determine the potential of this design to be scaled up for utility size rotorcraft primary flight controls.

PHASE II: Perform the detailed design, fabrication, and conduct performance and environmental test of the controller concept from Phase I. Analyze test results and perform a life cycle cost analyses. Apply lessons learned from test results and analyses to update the design and prototype. Mate the controller to an actuator and evaluate the unit at normal and extreme operating environmental and maximum load conditions with representative duty cycles. Collect data to substantiate the controller for airworthiness and reliability.

PHASE III: The Phase III objectives are to design, build, and evaluate a digital controller in an Unmanned Aerial Vehicle selected by the Government.

Phase III DUAL USE APPLICATIONS: All vehicles require a control system for attitude control and stabilization. Minimizing rotorcraft flight control system weight, volume and life cycle costs are goals germane to all aircraft. Commercial and military UAS use similar centralized electro-mechanical based control system architecture. Thus, both user groups are concern with EMI and are burden with the technical and cost constraints required to provide EMI protection. The technology from this effort will provide alternatives applicable to commercial and military UAS. It will provide cost effective means for commercial and military users to add, upgrade, integrate instruments/equipment and implement system choices. The user benefit is improved efficiency in ownership of UAS and control system. Also a goal of this effort is to provide open, interoperable standard based electro-mechanical technology. Thus this technology will be global in its application and could potentially meet the flight control system needs of all deployed and developing commercial and military UAS and manned rotorcraft.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Increased objective force readiness and reduced O&S cost of control systems via replacement of hydro-mechanical actuation with electromechanical actuation systems.

REFERENCES:
2) SMART Actuator Development Program, August, 1990, Report No. NADC-90076-60

KEYWORDS: Unmanned Aerial System, electromechanical actuation, flight control systems, fly-by- wire controls, fly-by-light, digital flight controls

A04-080 TITLE: Combat Rotorcraft EMI Suppression Technology (CREST)

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Electronics

ACQUISITION PROGRAM: PM Aviation Mission Equipment
OBJECTIVE: Investigate and validate an electromagnetic interference (EMI) suppression system that can be applied to US Army combat rotorcraft avionics equipment.

DESCRIPTION: The Army is transforming its aviation assets to recapitalize, modernize, and upgrade the manned helicopter fleet and to develop rotary wing Unmanned Aerial Vehicles (UAVs). Avionics enhancements to improve combat effectiveness, add functionality, contend with obsolescence, reduce costs, and capitalize on open source standards and commercial-off-the-shelf technologies are essential to the upgrade plans and to fielding low-cost highly capable rotary wing UAVs. Frequently, program offices cannot make avionics changes because the Electromagnetic Vulnerability (EMV) and EMI testing required when avionics equipment is changed or added to an aircraft make these changes cost prohibitive. Incorporating new or upgraded avionics in aircraft requires system level EMV and related EMI tests that generally cost program offices approximately $500K each time re-qualification is needed, and these costs are constantly rising. The Army could avoid significant re-qualification costs and allow easier and quicker avionics changes if a way could be found to eliminate the additional system level test requirements without compromising safety. Other military and commercial rotorcraft as well as fixed wing aircraft in both the military and commercial market could also utilize this material and theory. Unmanned Aerial Vehicles (UAVs) will face similar challenges with their avionics suites since safety will be just as large a concern as it is for manned aircraft.

CREST seeks to develop and test a broadly applicable avionics EMI suppression system comprised of new technologies or materials that eliminate or significantly reduce requirements for conducting electromagnetic/electronic environmental effects (E3) testing of Army combat rotorcraft when changes occur to the mission avionics suites. Offerors may consider material solutions to include avionics enclosures, coatings, blankets, shielding, wraps (including lossey coverings), derived neutrals or local grounding, or other exotic techniques (e.g., active cancellation) for suppressing EMI emissions. The solution may be used in combination with modified test or implementation procedures to achieve the goal of reducing the need for E3 re-testing after avionics modifications to an aircraft. The offeror should optimize the design to mitigate cost of implementation and weight and to be flexible enough for application to a wide range of military rotorcraft. Any new material that is developed must limit the effects of size and weight on aviation mission equipment. The new material developed should not impose unnecessary burdens on the Army logistics system or aircraft maintenance personnel or compromise flight line or in-flight safety. It should also be environmentally inert and airworthy. Modified procedures may rely on modeling and analytical techniques to reduce E3 test requirements as long as these techniques are vigorous enough to be accepted by flight release authorities in lieu of actual testing.

PHASE I: Design a concept for and determine the technical feasibility of an avionics EMI suppression system. Compare and contrast it to other candidate solutions. Define implementation and test processes and address impact to overall EMI suppression, durability, cost, logistical and maintenance systems, weight, and other factors as necessary.

PHASE II: Define associated processes, develop and document the system, and test the prototype system and procedures in a relevant avionics environment.

PHASE III DUAL USE APPLICATIONS: The offeror will research and market potential applications to other DoD aviation weapon systems and to commercial aviation.

REFERENCES:
1) MIL-STD-461, Electromagnetic Emissions and Susceptibility, Requirements for the Control of Electromagnetic Interference.
3) DO-160, Environmental Conditions and Test Procedures for Airborne Equipment.

KEYWORDS: electromagnetic environmental effects, electromagnetic interference, avionics

A04-081 TITLE: Automated Air Traffic Control (ATC)
TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Research the feasibility of using a fully automated Air Traffic Control (ATC) in a joint military battlefield simulated environment. This research should encompass analysis of current technology and the use of future technology. This effort should investigate new approaches to modeling air traffic and determine what approach is appropriate given various circumstances in the field and establish a road map for accomplishing this task.

DESCRIPTION: The Army has an array of highly immersive flight simulations/simulators using manned, unmanned, fixed wing, and rotor wing aircraft, including many types of missiles, covering all branches of the services with each system flying in the same airspace. The problem is there currently exist no fully automated battlefield Air Traffic Controller (ATC) to interact and direct pilots of other aircraft and missile zones. Often this controller is simply omitted in simulations, forcing each aircraft to fend for itself. If not left out totally, the controller has to be manned by multiple personnel and simulations, which add cost and time to the experiment. Without a system in place for controlling the virtual airspace, the simulation will lack full experimentation capabilities. Correctly simulating a true ATC is challenging in a virtual environment. Implementing voice and data messaging via an interactive tower and correctly identifying all flying entities, in a joint battlefield, has never been done. In a simulated war fighting exercise all this data must be modeled accurately and quickly. It must represent the behavior of the ATC controller in a tactically correct and responsive way. Programs doing work in this modeling and simulation (M&S) area include: Modular Semi-Automated Forces (ModSAF), OneSAF, Advanced Tactical Combat Model (ATCOM), Interactive Tactical Environment Management System (ITEMS), and many others.

We are searching for a method to pull new technology and legacy systems together to research and explore concepts for an Air Traffic Controller (ATC) that is capable of running at an acceptable level of performance for both concept evaluation and system performance studies. Technology to be used included in this study should consist of, but not limited to, voice recognition and response, cognitive decision aids, computer-generated forces, three-dimensional audio, and real-time distributed simulation. This would not be an effort to develop, build, assemble, or program a solution but to gain firm analytical answers for the level of effort and cost for developing such a system.

The benefits are numerous, including: filling a void in battlefield aviation and weapon simulations in the area of battlefield airspace management, reducing air space confliction, serving as a test bed for future ATC functions, and eliminating the need for man-in-the-loop ATC station which translates into lower overall cost as well as accuracy.

This technology will filter into the commercial world for all flight simulations used around the world in all types of aircraft and across all military branches of service. This will also leverage the multi-purpose technologies developed within government facilities.

PHASE I:
1. Research the baseline feasibility of using a fully simulated and automated Air Traffic Control (ATC) in a joint military battlefield simulated environment.
2. Investigate requirements for a simulated automatic Air Traffic Controller (ATC) capability.
3. Research common user interfaces for simulation management and control of the simulated ATC.
4. Study a plan for communication between ATC and aircraft in the designated test airspace.
5. Evaluate the ability to tailor multiple aviation applications, such as: flight dynamics, human factor study analysis, and various simulation data sets.

PHASE II:
1. Use the knowledge gained from the research and study in Phase I to propose new and inventive approaches to solve the task of an automated ATC.
2. Define data requirements to pass necessary information between the automated Air Traffic Controller and other aircraft.
3. Determine a simulation framework that is tailorable to various tactical aviation applications. The tailorability must include the ability to modify the following aspects of the flight simulator: flight dynamics, voice recognition command sets, simulation interoperability data sets, and mission planning functionality.

4. Collect user and Government representative inputs concerning improvements, problems, or concerns.

5. Provide a prototype system which has been researched and determined to provide a solution to meet the goals and objectives set forth in Phase I and the first four parts of phase II.

PHASE III:
Explore additional applications of this technology to other weapon and defense systems or to commercial applications such as ground based weapon systems, artificial intelligence and cognitive reasoning.

REFERENCES:
1) Air Traffic Control Simulators (Advanced Flight Controller Simulator)
http://www.etcsimulation.com/sim_airtraffic.htm
2) Air traffic control students receive new simulator
http://www-tradoc.army.mil/pao/TNSarchives/August03/newATC simulator.htm
3) Expeditionary Force Experiment
http://www.mitre.org/news/the_edge/august_98/sixth.html

KEYWORDS: Air Traffic Control, ATC, simulated, voice recognition, cognitive decision aids, interactive tower, computer generated forces, three-dimensional audio, and real-time distributed simulation, UAV, rotor craft, fixed wing

A04-082 TITLE: Advanced Flow Control Actuators for Fuselage Drag Reduction

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PM Comanche

OBJECTIVE: The objective of this solicitation is the design of a new class of prototype flow control actuators for closed loop rotorcraft fuselage drag reduction. The goal of the design is to develop candidate actuator prototypes and separation sensors that can be easily installed under or on an airframe skin. The new class of prototypes must be rugged, light-weight, compact, and meet extreme performance specifications.

DESCRIPTION: As advances in blade and airfoil design reduce the rotor drag contribution to the overall helicopter performance, the fuselage becomes a major source of drag -- limiting range, maximum speed, and specific productivity (Refs. 1 and 2). This is true for both full-scale aircraft as well as for UAVs. One of the foremost conflicts facing designers of next generation rotorcraft is the balance between improving utility without degrading the aerodynamic efficiency of the fuselage. For example, special operations aircraft often require non-aerodynamic mission equipment to be attached to the airframe, and these obstructions to the flow around the fuselage can be a large source of interference drag. It has recently been shown in US Army wind tunnel and flight tests that a typical transport aircraft can have large amounts of flow separation around the fuselage -- depending on the configuration of the various mission equipment packages. Wind tunnel tests have also shown a large potential for the application of active flow control using oscillatory momentum injection for rotorcraft drag reduction (Ref. 3-7).

While the active separation control concept works in a laboratory environment, the next step towards fielding the technology is to develop flight worthy flow control actuators (Ref. 6). Because of the extreme requirements of applying this concept to flight, this project involves development of an entirely new class of actuator prototypes unlike any existing designs. In order to meet both the performance and durability demanded by the typical rotorcraft operational environment, innovative, high-risk concepts must be explored. Current state-of-the-art actuator prototypes are not designed to survive in a rotorcraft flight environment. In addition, the large weight and 50% efficiency of off-the-shelf power amplifiers used to drive the actuators can offset the performance gains from flow control.
PHASE I: This problem first requires the prototype development of: (1) rugged, compact, light weight, and efficient flow control actuators, (2) light-weight, efficient power amplifier hardware, and (3) rugged surface mounted flow separation sensors. The results of Phase I should include performance testing as well as endurance testing of several prototypes. The endurance testing should include the effects of water, dust, icing, external sound pressure levels, and vibration. In addition, several of the prototypes should be tested to failure in order to identify the various modes and issues associated with harsh environments over long operating times. In order to maximize the benefits of this research to the US Army, the testing must be accomplished with full-scale components representative of military transport application. These results should provide useful guidance for Phase II as well as demonstrating the necessary expertise, knowledge, and experience to perform the required Phase II development.

PHASE II: The primary task is to develop and demonstrate prototype actuator/sensor integration into a full-scale helicopter fuselage structure. The primary innovation in this Phase is to retain the bench-top performance while designing prototype actuator installations within the constraints of an existing fuselage structure. The prototype design will address any cooling requirements, venting, and pressure equilization across the actuator. Performance of the prototype actuator/sensor assembly must be verified after installation in the final configuration including the above mentioned effects of water, dust, icing, external sound pressure levels, and vibration. A final analysis of total prototype weight and efficiency including power amplifiers and installation hardware as well as analysis of power required must be included in the final report. In addition, an estimate of total actuator endurance under harsh conditions in the form of (performance/power required -vs- time) should be included with supporting data.

PHASE III DUAL USE APPLICATIONS: The development of full-scale flight worthy flow control actuators/sensors is an important development for several DoD programs involving rotorcraft. A successful prototype design would be flight tested to validate the actuator performance and better understand the fundamentals of active flow control in flight. The research program would be an important first step in the development of low drag next generation rotorcraft, as well as for opening new avenues for legacy fleet upgrade programs and high performance VTOL UAVs.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Military rotorcraft operating in hostile environments require long range and high forward speeds to assure mission performance. The resulting design advances proposed by this study would reduce operation cost via increasing mission effectiveness and decreasing fuel consumption.

REFERENCES:

KEYWORDS: active flow control, closed loop separation control, turbulent boundary layer flow physics, separation sensors

A04-083 TITLE: Advanced Stress Measurement Technologies for Small Turbine Engines

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes
ACQUISITION PROGRAM: PM, Utility Helicopter

OBJECTIVE: Develop and validate turbine engine stress measurement technologies that are innovative, unique and offer significant benefits to development and maintenance cost reduction.

DESCRIPTION: Advanced turboshaft engines are expected to be required to support future Army manned and unmanned future force systems (i.e., A160, UCAR, Future Combat System, Future Utility Rotorcraft). It is anticipated that this will involve new centerline engines with a 20-35% reduction in specific fuel consumption (SFC), a 50-80% improvement in shaft horsepower to weight, and a 35-50% reduction in production cost. These turboshaft engine goals are acknowledged to be highly aggressive. To achieve them will require technology leaps. Another very important aspect of these systems is the need to successfully develop these systems with low development and maintenance cost so that they are affordable in today’s funding environment. High Cycle Fatigue (HCF) life issues often arise during engine development and operation leading to a significant increase in development and maintenance cost. The objective of this topic is the development and validation of turbine engine stress measurement technologies that are innovative, unique and offer significant reductions in development and maintenance cost through the ability to robustly measure and resolve these HCF excitations early in the development phase. Such technologies could include high speed slip rings (with ability to operate at rotational speeds of 50,000 rpm and higher and at high temperatures) to enable robust strain gage measurement of HCF critical components during advanced engine development efforts. Additionally, it could include advanced Non-intrusive Stress Measurement Systems (NSMS) which can operate in the high temperatures and unique geometries of small turboshaft engines (i.e. impeller exducer sections). Uncooled operation to at least 1000° F is required. In addition to the increased temperature capability, these sensors must provide increased spatial resolution, plus must be physically smaller than the existing NSMS sensors to facilitate installation in the cramped environment of small engines. The result will be more robust, HCF free, high-performance engine components, which are still affordable. This achievement will consequently lead to a significant reduction in development and operating and support (O&S)/logistics costs by significantly reducing the occurrence of HCF failures during engine development testing and during use in the field. In addition to increasing operational readiness, this technology will also enable the use of more aerodynamically advanced blade designs, which, without this technology, would not be able to affordably meet HCF life requirements. This will ultimately lead to increased engine performance thereby providing increased range and fuel savings for future rotorcraft. The resulting increased range and reduced logistics footprint/cost is in direct support of the future force.

PHASE I: Establish the feasibility of proposed technology to effectively allow or enhance the measurement of stresses in rotating hardware of small advanced turboshaft engines.

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

PHASE III: Focus on the commercialization of the technology through integration into engine manufacturer’s propulsion systems for use in future engine development programs.

DUAL USE APPLICATIONS: The resulting effort will develop advanced turbine engine stress measurement technologies for reduced development and O&S cost, which will be applicable to both military and commercial gas turbine engine markets.

REFERENCES:
1) Aerospace Industries and Test Measurement Divisions of ISA 45th International Instrumentation Symposium, May 2-6, 1999, Albuquerque, New Mexico; Overview of Pratt & Whitney NSMS, Robinson, Woodrow W.
A04-084  TITLE: Oil Free Couplings For High Speed Turboshaft Engines

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: The objective of this effort is to develop and demonstrate innovative oil-free methods of connecting future turboshaft/turboprop aircraft engines with their driven loads.

DESCRIPTION: The Army is anticipating the development of new centerline turboshaft engines for use in future manned and unmanned aerial vehicles (UAV) of the Future Force (i.e., UCAR, Future Combat System). These engines will be developed under the DoD/NASA DOE Versatile Affordable Advanced Turbine Engine (VAATE) initiative. Efforts are currently underway to eliminate liquid lubrication from these future turboshaft/turboprop engines by supporting the gas generator and power turbine shafts with conformal air/foil bearings or magnetic bearings. This desire stems from the speed and temperature limitations of liquid lubricated bearings and the large amount of maintenance that they require. Current turboshaft/turboprop engines utilize oil-lubricated involute splined shafts to connect the power turbine to a speed reduction gearbox for either a propeller or a helicopter main rotor. Full realization of the benefits of the future oil-free turboshaft engine will require an oil-free method of connecting the high-speed engine output shaft with these speed reducers. The currently used splines are typically crowned to allow limited misalignment. A separate flexible coupling mounted to the shaft absorbs additional misalignment. Material is typically AISI 9310 high strength case carburized steel. The splines are typically ground to achieve high precision and thus load capacity. The splines allow for very easy, reliable assembly/disassembly and can accommodate axial movement due to thermal growth or relative motion between the engine and the gearboxes. The splines also provide an inherently balanced configuration with very low vibrations. Grease packed splines have been used in the past but have proven to be heavy and require frequent inspection and servicing. Offeror’s should size their concepts to transmit 1200 hp at 30,000 rpm. The design should have a 5000 hr design life with an infinite fatigue life and require no servicing or inspection. The design should be capable of being connected and disconnected without the use of tools, accommodate misalignments of 0.001 in./in, axial movements of 0.25 inches, result in no dynamic instability in the drive train system, and operate continuously at 400 degrees Fahrenheit.

PHASE I: The objective of Phase I is to conduct a detailed design of the proposed concept. Detailed design should be followed by small-scale rig or bench evaluation of the critical technical challenge associated with the proposed concept. The results of these evaluations should identify the potential of the concept for satisfying the topic objectives and reduce the risk of full-scale development and demonstration in a Phase II effort.

PHASE II: The Phase II objectives are to further develop the selected concept and design and fabricate a full-scale prototype. The prototype shall be dynamically tested in a rig that simulates the expected engine operating conditions. Testing shall be sufficient to evaluate the performance, reliability, and durability of the proposed concept.

PHASE III: The resulting technology will be applicable to both military and commercial aircraft turbine engines. The technology would allow the implementation of the future oil-free high performance turbine engines into a host of vehicle applications that would benefit from the reduction in maintenance cost and increased performance. Potential commercial applications include turboprop powered aircraft where the oil free coupling would provide a
connection between the engine and propeller gearbox. A similar application would be for small ground based emergency generators which use a gas turbine to drive a generator for hospitals or remote locations. High speed ferries using gas turbines as there prime power source could also benefit. Specific military applications are for turbine powered helicopters where the oil free coupling would be used to connect the gas turbine to a gear reducing gearbox that drives the main rotor. The VTOL version of the JSF could also benefit in that the lift fan drive shaft could become a oil free device and thus have much greater reliability and less maintenance.

REFERENCES:

KEYWORDS: Splines, Couplings, Foil Bearings, Magnetic Bearings, Turbine Engines

A04-085 TITLE: An Aerodynamic Tool for Rotorcraft Brownout Analysis

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PEO, Aviation

OBJECTIVE: This solicitation seeks a reliable means for the analysis of the flow of rotorcraft, in proximity to the ground, and other objects that can be present and affect the overall flow, in a dust/sand/snow laden environment, leading to a "brownout" (or "whiteout") condition - and the presentation of that analysis in a manner that enables the identification, analysis and evaluation of visibility issues. Rotorcraft operations occur in a wide variety of environments and are strongly influenced by the rotor flows and the interaction of those flows with an environment that ideally consists of level ground (but not necessarily). Moreover, the ambient wind conditions that are encountered are ideally steady and well known, but this is often not the case and often because of the influence of the rotorcraft's own downwash. The resulting global flow resulting from the interaction of a rotorcraft with the ground environment and the overall flow environment is highly complex and not well understood in general. In extreme cases such flows can have a strong adverse effect on handling qualities. But even in less extreme conditions, there is a critical operational safety issue when the environment contains loose particles (dust, sand, snow, etc.) that can freely enter the global flowfield and obstruct visibility. The object of this solicitation is to develop the means to analyze a general flow field so as to model a resulting distribution of airborne particulates (generated by the rotors global flow field) and a graphic presentation of this flow field in a manner that will permit an identification of possible visibility difficulties, the magnitude and distribution of these probable difficulties, and the development of possible mitigation schemes.

DESCRIPTION: The problem requires development of a practical analysis method for the total flowfield of any typical or possible rotorcraft operating in a near-ground environment with a wide range of ambient flow conditions. The analysis should be physics-based and include all relevant phenomena capable of influencing the global flowfield, ultimately including the directionality, strength, and gustiness of the ambient wind, the presence of major ground topology features, the approach path, the rotor flowfield structure (as appropriate to the problem and well as it can be reasonably known), and possible interference effects (including other rotorcraft). The resulting computed flowfield should be presented in a manner that realistically visualizes the effects of airborne particulates (both ambient and those swept from the ground by this flowfield) showing the effect of the flowfield on opacity as seen by various observers, especially the pilot. The method should be fast and convenient enough to be useful to users, who are not computational experts and should include the capability to adjust the airborne particulate generation as a function of the known nature of the particles and the flowfield.

PHASE I: Devise and demonstrate a proof-of-concept (for example, comparison to measured outwash data, see Ref. 2) for an analysis method that demonstrates the ability to compute the flowfield about a single rotorcraft, operating near the ground and thereby generating a particulate cloud that reflects the flowfield. The flowfield
should be shown to be well representative of what is known about rotor operation close to the ground with a wind blowing. The visualization of this particulate cloud should have a realistic appearance, making it a good candidate for simulation use, and with an opacity distribution that reflects the flowfield. The opacity should also be presented in a qualitative manner suitable for validation testing. This model should be capable of demonstrating various approach paths and speeds and the effect of these on opacity. The method should contain an ability to vary the particulate generation rate and thereby permit tuning of the visibility model based on experiment. An understanding of the limits of the method should be demonstrated. Experiments needed for support of this specific model development should be recommended and described if they are deemed to be necessary. Such tests (preferably of a joint nature to be conducted at or using Army facilities) can be proposed as part of Phase II work, if such work does not excessively dilute resources needed for model development (but such tests should be performed on a scale appropriate to early validation).

PHASE II: Integrate the proof-of-concept elements into a general method to include more detailed rotor downwash modeling, multiple rotors, variable ground topology, general approach-path modeling and wind variability. Demonstrate the ability to change theses features quickly in response the changing needs or as a tool to develop optimum approaches for varying conditions. Demonstrate the accuracy of the predicted flows and and resulting opacities using existing data (if such exist) and/or other available analysis (as appropriate, say for particular flow situations). Conduct or cooperate in basic experiments (if so proposed under Phase I) showing the accuracy of the predicted flows and the resulting opacity distributions.

PHASE III DUAL USE APPLICATIONS: Visibility difficulties can occur in all types of utility rotorcraft operations, military or civilian, the primary difference being that, for the latter, cancellation of operations will only cost money. The anticipated tool would make it easier for an operator (military or civilian) to understand the effects of his environmental conditions on visibility and plan accordingly. It is anticipated this tool will enhance the operational "rules-of-thumb" that an operator will use for such planning as well as provide a detailed planning aid for specific and difficult conditions. A properly packaged tool (with appropriate front end, interfaces and operability improvements) would be an excellent commercial product for military or civilian application. Obvious Phase III work could entail this product packaging and/or extended testing to refine the accuracy of the method.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The cost savings envisioned here have to do primarily with ensuring the success of a mission - that is, doing it right the first time. A knowledge of the particulate environment may also allow operations that reduce rotor and engine erosion. The biggest factor is probably a reduction of the extreme danger of sudden zero-visibility operation. An ability to better understand, and to do something about, the factors governing visibility will increase the success rate of operations, reduce maintenance costs, and save lives.

REFERENCES:

KEYWORDS: rotor wakes, rotor global flow-field, visibility

A04-086 TITLE: Single Crystal Piezoelectric Actuators for Rotorcraft

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: The objective of this effort is to develop single crystal piezoelectric actuators for rotorcraft structures applications.

DESCRIPTION: Research has been performed over the past several years on exploiting smart materials, including piezoelectric ceramics, in rotorcraft structures with the promise of reduced rotor and airframe vibrations, reduced
noise leading to reduced detectability, improved performance including increased range and lift, delayed dynamic stall, and swashplate-less rotor designs. Piezoelectric actuators are currently being developed for rotor blade trailing edge flaps, active rotor blade twist, and other rotor and airframe vibration control approaches (see for References 1-5 for a fraction of the current research). The effectiveness of the current piezoelectric actuators is often limited by a low stroke output (strains on the order of 0.15%) and a large required voltage (in some cases up to 1000V).

Recent research has shown the potential of single crystal piezoelectric actuators (Ref 6-7) in overcoming these limitations and may allow the potential of smart materials to be realized by producing actuators with strains on the order of 0.5 to 1% and 3 to 5 times the strain energy density of conventional piezoelectric actuators. This effort should focus on maturing single crystal piezoelectric technology such that practical single crystal actuator for rotorcraft applications may be developed. The proposal should address the single crystal actuator performance (strain level, force output, energy density), weight, required power, structural integrity, fatigue life, and cost relative to current piezoelectric actuators. Development of a practical single crystal piezoelectric actuator will benefit nearly all of the current rotorcraft related piezoelectric actuator research by providing a larger actuator stroke output at a lower required power than and at a cost near current actuators.

PHASE I: Phase I should focus on the development of a practical single crystal actuator. Characterization of an appropriately scaled actuator to include as a minimum strain and force output, power required, and structural integrity should also commence in this phase.

PHASE II: Actuator characterization should continue in Phase II. A single crystal piezoelectric actuator should be scaled, designed, fabricated, and demonstrated in a rotorcraft application, e.g., in a bench test simulating a full scale rotor blade trailing edge flap under representative aerodynamic, centrifugal, and inertial loading (Ref 3), as a product of this phase.

PHASE III: This phase should complete actuator development and characterization to demonstrate the potential applications to all rotorcraft, both military and commercial, manned and unmanned. The single crystal actuators developed will also have applications outside of rotorcraft ranging from sporting goods to medical equipment.

REFERENCES:

KEYWORDS: single crystal piezoelectric actuators, rotorcraft vibration control, smart materials
OBJECTIVE: Develop and validate a comprehensive methodology and software tool for timely and cost effective implementation of advanced environmental barrier coating (EBC) technology to ceramic matrix composite (CMC) components for both military and commercial turbine engines.

DESCRIPTION: In addition to increased life, the use of CMC components with EBCs can result in significant reduction in component weight by alleviating thermal gradients and thereby reducing cooling system requirements. The resulting increase in thrust to weight ratio of engines provides a strong incentive for turbine engine manufacturers to be keenly interested in further developing coating technologies.

The most recent developments in EBCs have occurred in the EPM project (under NASA’s High Speed Research Program). Preliminary results indicate that coatings provide a viable means of enhancing service life of CMC combustor liners. There has been no significant progress in developing design and life prediction methods for coated CMC components. The coatings technology for CMC components is still in its infancy.

A more systematic coatings technology development process based on an improved mechanistic knowledge base would not only be more cost effective, it would help develop optimal coating systems for specific applications and for specific substrates (such as SiC/SiC and SiC/SiN composites). Mechanistic models for predicting damage progression and failure of coatings would replace expensive trial-and-error approaches of developing improved coatings. Accurate and fundamentally based life prediction models would enable reliable and cost effective evaluation of coating systems for specific applications, minimizing the need for long and expensive development and testing programs. Accurate life prediction techniques would help ensure structural integrity and adequate life of coating systems under engine operating conditions. The payoff of developing a systematic design and life prediction methodology for coatings is too significant to be overlooked.

PHASE I: Establish the feasibility of the proposed technology for developing and validating a comprehensive methodology and software tool timely and cost effective implementation of advanced environmental barrier coating (EBC) technology to ceramic matrix composite (CMC) components

PHASE II: Working with a turbine engine manufacturer develop a detailed software tool and experimentally validate the technology based on real engine CMC components.

PHASE III: Focus on the commercialization of the technology through integration into engine manufacturer’s propulsion systems for use in current and future engine component development.

DUAL USE APPLICATIONS: The resulting effort will develop a software tool needed by designers for timely and cost effective implementation of advanced EBC technology to CMC components for both military and commercial turbine engines.

REFERENCES:


KEYWORDS: Gas Turbine Engines, CMC, EBC, Coatings, Rotorcraft, Materials
TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Pm Comanche

OBJECTIVE: Development of analysis capabilities for active flow control concepts and integration into general rotorcraft analysis tools.

DESCRIPTION: Active flow control (AFC) concepts, such as synthetic jets, plasma actuators, and MEMS, are showing promise and viability for rotorcraft configurations. Experimental research has shown successful application to airframe download reduction, stall delay, and tip vortex alleviation. State-of-the-art time-accurate computational fluid dynamics (CFD) calculations have been performed on a range of configurations, however, these simulations are typically computationally and labor intensive. For example, current modeling of pulsed, synthetic jets spatially models the jet outlet as well as the temporal oscillations. MEMS simulations currently require detailed modeling of small actuators. These geometric and temporal fidelity requirements place a high demand on computational and manpower resources. For analysis of AFC concepts in rotorcraft comprehensive codes, so as to take into account dynamic as well as aerodynamic effects, it is typically necessary to develop airfoil tables utilizing the flow control devices. The tables, which detail lift, drag, and pitching moment as a function of angle of attack and Mach number, can be expensive to develop, either experimentally or computationally.

In order to obtain the most advantage from AFC concepts, it is desired to develop alternative modeling or analysis capabilities. These models would supplement the current spatially- and temporally-accurate CFD analyses or comprehensive code airfoil table look-up. The new models should be faster and more efficient than current capabilities such as those mentioned above, while maintaining a certain level of accuracy in comparison. They should be integrable into general state-of-the-art rotorcraft computational tools, such as comprehensive analysis or CFD. Manpower requirements may also be improved over current capabilities. The actual form of the model, flow control device modeled, and any specific rotorcraft configuration is left to the proposer.

As examples only, a CFD model for oscillating jets may be envisioned which does not require costly temporal accuracy. One such model could be developed as a turbulent kinetic energy boundary condition based on empirical studies of synthetic jets. Or a model may be suggested for comprehensive analyses that is an incremental approach to baseline, uncontrolled airfoil tables. The increments may be determined by an analytical model of the aerodynamic effects of the flow control device.

In general, innovative solutions are encouraged so that AFC concepts can be more easily integrated into the analysis and design cycle and applied in a timely manner. Improved analysis capability would allow faster implementation of AFC on current Army rotorcraft undergoing drag reduction and performance improvement programs. The flow control concepts could also be more easily applied across the entire flight regime, allowing improved integration into an optimal helicopter design.

PHASE I: Development of initial analytical/computational models for active flow control concepts. Validation of the model with published rotorcraft model problems. Plan for implementation in general rotorcraft analysis tools.

PHASE II: Refinement of Phase I models and implementation in rotorcraft analysis tools. Demonstration and validation over a range of helicopter operating conditions.

PHASE III DUAL USE APPLICATIONS: The ability to analyze the effect of flow control concepts into an integrated helicopter design has numerous applications to modification of existing rotorcraft and development of future vehicles. Several rotorcraft analysis tools are currently in use which would benefit from flow control modeling capability.

REFERENCES:

KEYWORDS: active flow control, synthetic jets, oscillatory jets, zero net mass jets, plasma actuators, MEMS, comprehensive analysis, CFD, download, stall, tip vortex

A04-089 TITLE: Ducted Fan Model for Real-Time Rotorcraft Flight Simulation

TECHNOLOGY AREAS: Air Platform, Information Systems

ACQUISITION PROGRAM: PM Comanche

OBJECTIVE: The objective of this effort is to develop a ducted fan analytic math model for real-time flight simulation applications.

DESCRIPTION: Current state-of-the-art real-time rotorcraft simulation models implement a uniform inflow momentum theory based model of the anti-torque device. These models are computationally efficient and provide reasonable fidelity for traditional tail-rotor configurations. However, ducted fan anti-torque devices have been adopted for some modern rotorcraft designs such as the Comanche helicopter and the U.S. Coast Guard’s HH-65A “Dolphin”. In addition, Unmanned Air Vehicles (UAV) rely heavily on the ducted fan concept for both primary source of lift and anti-torque. Due to the close proximity of the fan blades to the duct, the ducted fan design experiences non-uniform inflow throughout much of the rotorcraft flight envelope. Depending on flight condition, the duct-fan configuration also experiences the interference from the main rotor as well as fuselage wake. These aerodynamic interactions can have significant impact on the rotorcraft performance as well as stability and control. Although significant progress has been made in Computational Fluid Dynamics (CFD) tools to model ducted fans, there remain unresolved issues about the robustness, numerical stability, and accuracy of these methods. An innovative approach is needed to develop an analytical ducted fan model that can be integrated into a comprehensive flight simulation model and tested for real-time applications. The comprehensive flight simulation model will fully address all aspects of a physical rotorcraft system including rotors, airframe, propulsion and flight control in support of design, handling qualities analysis, test and evaluation, and training.

PHASE I: The objective of Phase I is to perform a design/feasibility study for an analytic math model of a ducted fan. This study should consider individual contributions from the duct and the fan to the total ducted-fan thrust for axial and non-axial flight. The goal is to develop a model that minimizes the reliance on empirical data to accurately predict torque and thrust for axial and non-axial flow.

PHASE II: The objective of Phase II is to develop and integrate the Phase I model into a ducted fan configured rotorcraft simulation capable of real-time operation and validate against flight test data. This model should be a comprehensive model including all aspects of a physical rotorcraft system such as rotors, airframe, aerodynamic interactions, propulsion and flight control in support of design, handling qualities analysis, test and evaluation, and training. The aircraft used for validation may be a manned or unmanned, military or civilian application dependant on available data.

PHASE III: The objective of Phase III is to produce a Commercial-off-the-Shelf tool that can be used to develop complex aircraft models that include a ducted-fan. It is anticipated that these models will be incorporated into training simulators and/or engineering development simulators. It is anticipated that these models will greatly improve both commercial and military simulators used for both procedural and proficiency training as well as desktop simulation design analysis, design optimization and simulation based acquisition.

DUAL USE APPLICATION: Ducted fans are used in commercial applications as well as military application. These applications not only include rotorcraft anti-torque devices, but also include propulsive devices on manned and unmanned air vehicles.

ARMY - 123
OBJECTIVE: The objective of this effort is to develop and demonstrate the extent to which flight control systems can use data from existing, on board, non-flight control sources to replace flight quality sensor information and still meet reliability requirements.

DESCRIPTION: US Army goal to transform the Objective Force to a single force, capable of maintaining the dominant survivability of present day heavy forces, while achieving the rapid deployability of present day light forces, is considered the “greatest challenge to development of truly viable, integrated leap-ahead operational capabilities” in the Army’s Future Operating Capability for Survivability. For aviation, reducing vulnerability to threats affordably is a key step towards achieving this goal. Self-repairing flight control systems offer the potential to significantly reduce vehicle vulnerability. An affordable self-repairing control system applies other resources, already on-board the vehicle, to provide equivalent sensed information to the control system. The vehicle relies less on physical redundancy to protect the crew and vehicle, saving weight and increasing volume available for mission equipment. Currently, Flight Control Systems (FCS) use only redundant flight quality sensors to meet reliability requirements. Maintaining reliability while requiring fewer dedicated and unique flight quality sensors may reduce costs, weight, and volume. This effort investigates using other existing onboard information to provide equivalent inputs to the FCS, ergo, reducing the number of flight quality sensors to meet reliability requirements.

PHASE I: This phase should consist of a functional analysis and reliability assessment. The functional analysis should determine if existing onboard non-FCS information could provide equivalent inputs. This usable information should be characterized for use as equivalent inputs to meet flight control system functional requirements. In addition, any gaps shall be identified and approaches defined to derive any requirements missing or higher-quality information from the existing information. Execute a reliability assessment to define the reliability impact of using this secondary information as part of a FCS.

PHASE II: This phase should consist of a sensitivity study and application of the results in Phase I. This effort should apply Phase I concepts to 2 manned and 1 unmanned Army rotorcraft, which have full authority digital control. A sensitivity study on 1 manned aircraft and 1 unmanned aircraft to identify the minimum quality of information required to maintain vehicle control should be performed during this phase. Using only secondary systems, the impact on the flight envelope should be analyzed and evaluated on all 3 aircraft. Where the secondary system information is not sufficient, propose and develop solutions for the aircraft to become more controllable.

PHASE III: This phase will demonstrate a flight control system using this secondary system on an unmanned aerial system (UAS). This may be demonstrated as a ground-based simulation or full operational flight test.

REFERENCES:  
1) Some work has been done in similar areas with fixed winged aircraft and with neural network techniques, but documentation is hard to come by.
A04-091  TITLE: Crashworthy Ballistic Tolerant Fuel Tank Weight Reduction

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM, Utility Helicopter

OBJECTIVE: The objective of this effort is to reduce the parasitic weight of crashworthy, ballistically tolerant fuel tanks 50% below the lowest weight system constructions at ~0.9 lb/ft², that have passed the Phase 1 qualification requirements of MIL-DTL-27422C (and predecessors). The threshold threat is 0.50 Caliber (all sides) and the objective threat is 14.5mm AP projectiles.

DESCRIPTION: Weight margins are shrinking as PM’s continue to try to satisfy user requirements on existing airframes. The pressure to reduce weight (and maintain performance) is a significant driver in technology programs. Both internal and external fuel tanks are required to meet the requirements of MIL-DTL-27422 (formerly MIL-T-27422); hence the desired technology is applicable to a broad range of aviation fuel systems. A major key to reducing tank weight is to strategically place the access panels and hose fittings away from areas where the major ballistic impact loading (hydraulic ram) usually occurs. In many cases, the major loading occurs within the lowest 6-12 inches of the tank bottom.

PHASE I: The proposer shall develop 200-gallon concept design(s) that weigh less than current crashworthy, self-sealing technology (Type I tank), and satisfy the program objective. Innovative approaches should consider fuel lines and fittings (including placement) in the overall goal of reducing system weight. Fuel systems should also be designed for easy removal and replacement at the unit maintenance level. Upon completion of Phase I, a report detailing the concept designs, which demonstrate the potential for meeting the program objectives, shall be presented with the proposer’s recommendations and rationale. Emphasis for consideration shall be placed on weight, scalability, and cost of manufacturing the design.

PHASE II: The proposer shall take the approved concept design(s) and construct a mock-up fuel system to be tested against the requirements outlined in MIL-DTL-27422C (Phase I) for Type I tanks.

PHASE III: The proposer shall fully qualify the selected design from Phase II, for a future or existing Army aircraft, to the requirements of MIL-DTL-27422C (Phase II) for Type I tanks. This technology is intended for military use, but may be extended to civilian commercial helicopter use as well. The proposer should identify how his concept design can be extended to dual-use applications.

REFERENCE:
1) MIL-DTL-27422C, Tank, Fuel, Crash-Resistant, Ballistic-Tolerant, Aircraft, 14 Jan 02.

KEYWORDS: ballistic tolerance, self sealing, crashworthiness, fuel tanks

A04-092  TITLE: Reconfigurable Multimodal Control Station (RMMCS) for UAV Control

TECHNOLOGY AREAS: Ground/Sea Vehicles, Human Systems

OBJECTIVE: The objective of this SBIR topic is to develop a relatively compact UAV control station (on the order of a tablet PC) that includes multiple modality input and outputs, e.g., manual/touch input, speech recognition,
visual, auditory and haptic (touch) feedback. The common hardware and software will be reconfigurable to suit a variety of control tasks both for different platforms by mimicking specific control stations, and for different crew functions, e.g., AVO and MPO. The technical challenges requiring innovation are both the coherent integration of multiple input/output modalities so they work cooperatively, and the reconfiguration process resulting in an operator interface that is at least as useable as the fixed-configuration control station for the particular system.

DESCRIPTION: Benefits to the Army accrue in two ways. First, multimodal control offers the opportunity for simpler and smaller control stations and a more “natural” control means through a combination of speech recognition and manual input as well as visual, speech, and haptic output. Multimodal control reduces the workload of the operator, i.e., offers the possibility of doing more tasks, and also reduces training requirements. The smaller size (fewer dedicated mechanical parts) and reduced weight is an important consideration for the Objective Force.

Second, benefits include those associated with commonality of multipurpose hardware, i.e., reduced inventory of hardware, availability of interchangeable units in case of failure, reduced maintenance personnel and training requirements.

Commercialization potential. Reconfigurable multimodal control stations could be easily extended to robotic systems for the FCS. In both the civilian and military sectors, an RMMCS would have application in satellite control, industrial process control, and mobile command and control centers for firefighting and natural disaster intervention management.

PHASE I: Develop functional design for multimodal control of two disparate UAV systems or system tasks that currently require fixed design control stations. Note: not all functions of the control station or UAV need to be included in the functional design. Develop detailed hardware and software design for multimodal interface and reconfigurability.

PHASE II: Build A prototype of RMMCS and demonstrate multi-modal and reconfiguration capabilities by control of two disparate, real or simulated, UAV systems or system tasks. Control of all system functions is not required.

REFERENCES:

KEYWORDS: multimodal, UAV, control station

A04-093 TITLE: Modeling and Analysis of Rotor Blade Erosion Phenomena/Mechanisms

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PM Utility Helicopters

OBJECTIVE: Develop and demonstrate analytical capabilities for predicting erosion impact phenomena.

DESCRIPTION: Rotor blade erosion impact phenomena cannot currently be accurately predicted. Current methods of screening potential Army erosion protection solutions suffer from this lack of basic knowledge and tools.
Laboratory testing of solutions is performed ad hoc, with little analytical basis to substantiate its validity, and requires a significant cost and time investment for the small amount of data obtained. Fielding of erosion protection materials in this manner often results in sub-optimized solutions which perform poorly in the field. Over the course of conflict, this leads to reduced A/C availability and significantly higher O&S costs.

Impact modeling and analysis of particulate erosion has been researched and studied for the past 3 decades. As computing power grows and more tools become available, this effort has progressed in stride. However, impact analyses are often performed on limited substrate materials with specific boundary test requirements. This niche technology needs further development and expansion to provide the DoD with a robust M&S capability to assign both substrate and particle parameters, as well as control the impact environment. With this new capability, significantly more erosion material solutions can be tested and reformulated and tested again at a fraction of the time and cost previously spent to test one sample. This will lead to far greater optimization of DoD erosion protection solutions and translate directly to benefits in A/C availability for the warfighter.

Developing and verifying complex erosion impact modeling and analysis will enhance the ability to evaluate materials and processes used in protecting assets against erosion. Models must be highly adaptable and able to utilize a wide array of possible environmental attributes. Models must be capable of providing impact analysis of various materials from polyurethanes to metals and advanced composite substrates based on material properties. Models must yield meaningful output possibly in the form of impact models and Time To Failure (TTF) calculations.

These models will provide analytical results, which in conjunction with empirical data, will provide a sound assessment of the potential of current and future erosion protection materials and processes. This process will yield significant flexibility and full optimization of erosion solutions for DoD rotorcraft.

PHASE I: Offeror must demonstrate proof of principle of significant analytical and modeling capability. Key erosion impact drivers (particle size, shape, speed, substrate) will be identified. Offeror will conduct feasibility study examining ability of technology to grow and meet DoD erosion requirements in Phase II.

PHASE II: Integrate all drivers into prototype modeling environment and demonstrate capability of the tool to accurately predict erosion mechanics. Model output formats as well as user interfaces will be finalized. Correlation with existing Gov’t provided empirical data will be used to validate the prototype.

PHASE III DUAL USE APPLICATIONS: Validate and verify the model for use as a tool in pre-screening and quantifying potential defense and civil erosion solutions. Erosion is a problem spanning numerous sectors of both defense and civil markets. Analytical tools capable of modeling various erosive environments would have widespread applicability to many aviation markets.

REFERENCES:

KEYWORDS: Rotor Blade Erosion, Modeling and Simulation
TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO, C3T

OBJECTIVE: The ever increasing complexity and high cost of developing new Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems requires a systematic approach to architectural analysis prior to actual design.

Developing operational, systems and technical architectures is the first step in developing new integrated C4ISR systems for the Army and DoD. Today, this process consists of many manual steps, limited discrete automation and is extremely labor intensive. Whereas there are some commercial tools for architecture design, none of these automated tools exist that meet both the DOD Framework Architecture guidelines for large numbers of nodes (approaching 100,000) and the needs of a fully integrated system which allows one to easily switch operational, system and technical views. Features required include the ability to track requirements, input data, and generate the graphical views necessary for the various operational, systems and technical views under the DoD Framework document. A means to develop this data within an integrated database with graphical and web-based views is critical to improve integrated C4ISR architecture work in the future.

In addition to being used as a systems design and planning tool, this product could also be used in a tactical mission during the task organization phase of planning. As units are task re-organized under the Army's new fluid structure prior to a battle, there is a need to re-organize the resulting C4ISR system and network on-the-fly to reflect the new organization structure and ensure that the new structure will work in both a functional and technical sense. By employing a role-based approach and utilizing innovative extensions to the existing DoD framework operational, systems and technical views, a tactical planning tool for C4ISR architectures can be added to the overall product.

DESCRIPTION: Currently, the commercial marketplace has limited systems architecture tools and none that meet all the Army's needs (i.e., generate all the required views in a complete DoD C4ISR architecture for the number of entities required for large systems (over 10,000) with input/outputs to commercial simulation tools). A unique web-based tool with both a text and graphical interface with interfaces to a back-end database needs to be developed that can simplify the process of both generating and modifying C4ISR architectures and their associated views.

Application of this tool will allow for the rapid generation of more accurate and maintainable integrated C4ISR architectures. This is critical for the fielding of future complex systems, such as Future Combat System and Objective Force Warrior, that capture and meet the user’s requirements both operationally and with respect to systems interfaces.

In order for this tool to be used both tactically and in a research and development environment during system design, research is needed to develop this tool as a services-based environment compatible with the emerging network centric enterprise system. This tool should be capable of being installed in tactical platforms to meet the planning needs of the G-6.

PHASE I: Evaluate existing commercial and government automated C4ISR architecture tools. Identify technology gaps to an integrated approach. After performing this analysis, develop a detailed systems and software design for a software-based C4ISR architecture and tactical task organization planning tool with both text and graphical web-based interfaces that can run on a standard commercial desktop platform using commercially-available databases (Core Architecture Data Model - compliant) at the backend, leveraging both government and commercial products to the maximum extent possible. This system should be capable of either stand-alone use or in a distributed client-server fashion over a secure Internet. Initial work in this area developed by various government teams (PEO C3T, CIPO, and a joint effort from the Communications-Electronics Research, Development, and Engineering Center (CERDEC)/MITRE/Computer Sciences Corp. (CSC)) will be made available and incorporated into design where technically sound and feasible.

PHASE II: Develop, implement, test, demonstrate and deliver an integrated prototype software-based system with associated test hardware (i.e., workstation/client, server) for a C4ISR architecture and tactical task organization
systems planning tool, based on the design from Phase 1 that leverages the best of existing commercial and government products. The design should also have a means of outputting standard architecture products through a transition interface to drive simulations using common simulation tools, such as OPNET.

PHASE III DUAL USE APPLICATIONS: Transition products to both the Army (PEO, C3T, PM, FCS) and commercial marketplace. The commercial market has similar architecture modeling needs for commercial business processes that are managed through a combination of automated systems interconnected within a network.

REFERENCES:
2) Analysis of DOD C4ISR Architectural Framework: http://www.sei.cmu.edu/publications/documents/03.reports/03tn027.html
5) Sample operational, system, tech views applied to business (not tactical) problem: http://www.dod.mil/comptroller/bmmp/pages/arch_arch_home.html

KEYWORDS: C4ISR architecture, modeling, simulation, systems architecture, systems design, task organization, tactical planning, network planning

A04-095 TITLE: Remotely Controlled Neutralization Techniques for Mine Clearance

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: Innovative research is required for creation of remotely controlled, stand-off precision mine neutralization technology. The innovative research shall result in technical solution(s) capable of destroying, negating, or deflagration of individual landmines at standoff distances. Proposed solutions shall be capable of a probability of kill of 0.95, precision standoff neutralization distances of 250 meters from the neutralization platform, a neutralization time of less than 2 minutes, and a neutralization platform rate-of-advance of 50 kph. The proposed solution shall not introduce a logistics burden to the military user. Landmine targets shall include mines laying on the surface to landmines with a 15 cm soil overburden (burial depth). The mine type shall include metal and plastic cased antitank mines. The precision standoff neutralization technology shall be capable of neutralization of landmines in on- and off-route environments. Operationally, this is to support maneuverability of a clear lane for troops to pass through safely.

DESCRIPTION: Currently a variety of ground vehicular, wide-area, mechanical landmine neutralization systems are employed by the Army. These systems have a standoff neutralization capability but they are overly burdensome to the user with respect to weight, power and fuel consumption, logistics support, and time to effectively neutralize a mine lane or minefield. In the case of line charges and explosive nets, for every landmine destroyed, there are areas neutralized which contain no landmines, resulting in wasted munitions. The proposed innovative research shall result in a technology that provides for a lighter weight system with remote control activation for precision standoff neutralization of individual landmines, as opposed to wide area neutralization. The system shall provide stand-off, precision neutralization and shall effectively neutralize mine(s) in a timely manner given mine/target positional information from a stand-off mine detection sensor system.

PHASE I: Pursue innovative research into the feasibility of a technical approach that will meet the aforementioned objective requirements for precision neutralization, standoff distance, rate of advance, probability of kill, reduced logistics burden, and reduced neutralization time. During this Phase, demonstrate proof-of-principle for the proposed technical approach, resulting in a demonstrator that is capable of providing precision standoff and effective neutralization of individual landmines in a timely manner. The device shall be remotely controlled to provide activation from a safe distance.
PHASE II: Develop and demonstrate a prototype standoff precision land mine neutralization system capable of performing in realistic environments against a wider variety of landmines and soil conditions. The prototype shall be suitable for experimental operation by the government. Upon completion of contractor and government experiments, further develop the prototype, based on government inputs, to address system robustness, operator ease of use, and improved performance.

PHASE III DUAL USE APPLICATIONS: This device will have wide utility in the civil engineering and construction areas, particularly in remote areas. This device with added sensors could be a benefit in the user community in response to booby trap threats.

REFERENCES:
1) "Proceedings of the SPIE AeroSense Conferences/Battlefield Technologies", 1995-present, website: www.spie.org

KEYWORDS: lightweight, remote control, precision, mine, neutralization.


TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

OBJECTIVE: The objective is to decrease the workload of the commander and his staff in planning for a more efficient and effective command and control of the unmanned system of systems to satisfy multifaceted priority and echelon needs simultaneously. This effort will develop advanced algorithms and methodology to aid the commander and analysts in assessing the suitability of existing data to satisfy mission and geographic directed needs for battlefield information. The effort will address the management and control of unmanned system of systems assets, priorities, search data acquisition and control parameters, data time of arrival, etc., for successful collateral mission planning directed at augmenting the existing battlefield picture.

DESCRIPTION: Unmanned systems can be used not only to keep warfighters out of harm’s way, but also to relieve warfighters of mundane tasks, thus allowing them more time to focus on their primary mission. As the use of unmanned systems increases throughout the Army, the issues involving managing these resources are becoming more complex. Research is needed to develop advanced algorithms that will assist the commander in planning for the utilization of unmanned assets under widely varying situations. The result will be a reduced workload and a more efficient and effective use of the unmanned resources. This SBIR topic addresses shortfalls identified in Battle Command integration of unmanned assets (Unmanned Ground Vehicle (UGV), Unmanned Aerial Vehicle (UAV), Sensors) expressed in the TRADOC Force Operating Capability Science and Technology Assessment related to FOC-03-01 Command and Control. The product of this effort is expected to provide resource allocation decision aid tools optimized for unmanned systems. These tools will be applied to the Networked Unmanned Ground and Air System (NUGAS) NUGAS will provide the commander focused access to the Global Information Grid (GIG) enabling him to reach-back to unmanned ground and air platforms and sensors to see first and act first in order to maintain superiority on the battlefield.

PHASE I: Initial investigations will focus on the feasibility on the development of independent transportable modular generic algorithmic tools as appropriate that handle critical information relative to unmanned systems and their respective mission. The study should address information critical to meeting the object of this task such as the following:

- Modeling airspace and ground space deconfliction
- Multi-tasking of multiple UVs
- Mobility and threat avoidance
- UAV and UGV platform performance
- UAV and UGV platform sensor data acquisition constraints
• Target and emplacement detection parameters
• Terrain feature and camouflage masking effects on targets and emplacements
• Overlays to improve searches for suspected locations of targets and emplacements
• Comparative sensor effectiveness in locating specific target or emplacements over varying terrain and environmental conditions
• Optimum search paths to detect specific target or emplacement types
• Sensor platform routing to effect optimum priority and collateral mission/event driven scenarios
• Risks and benefits for threat avoidance or encounter
• Mid-course corrections and control transfer paradigms
• Collaborative direction of outside UVs entering the commander’s area
• Automated reporting of full mission and mission segments.

A definitive roadmap, indicating the research, studies, and/or analyses that need to take place to determine the best set of generic algorithmic tools, are essential.

PHASE II: Based upon the results of Phase I, the Government will select the proposed algorithmic tools that provide the highest payoff at the lowest risk for Phase 2 development. The vendor shall develop these algorithmic tools and map based application modules as required. The tools will be integrated with a map-based product for demonstration, experimentation, and testing. Use of the application graphical user interface (GUI) shall be user friendly, and population of the generic algorithms shall be menu driven to illustrate the performance and detection characteristic of multiple various UVs and sensor types without reference to a specific product.

The modules developed in this phase are to be portable to other applications and operating systems.

PHASE III DUAL USE APPLICATIONS: Search and rescue missions, forest fire overall management, border surveillance, livestock/wildlife management and detection, etc.

REFERENCES: 1) Force Operating Capabilities, TRADOC Pam 525-66.

KEYWORDS: resource optimization, advanced algorithms, area search history, aging data extrapolation, data handling, collateral missions, collateral delays to primary missions, quantum data needs definition, fractional mission segment definition, fractional data envelope extraction, commanders’ priorities, individual priorities, prioritization methodology, mission priority optimization overrides, time to data acquisition, sensor to feature matching, visualization (map based, graphics, sequential, a/v alerts, tabular)

A04-097 TITLE: Self Contained Displacement or Velocity Sensor

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PM NAV SYS

OBJECTIVE: Future Combat Systems (FCS) and Future Force dismounted soldiers, robots, and autonomous sensor platforms will be required to operate in areas with poor radio-navigation availability, such as in buildings and caves. FCS Future Operating Capability (FOC-05-01) requires position/navigation to a 1-meter Circular Error Probable without continuous electronic emission. A self-contained navigation sub-system is desired to provide this capability. The topic calls for a displacement or velocity sensor to be used as an aid for the navigation system to be used in areas where Global Positioning System (GPS) signals are not available (e.g. buildings, tunnels, forested areas, and high electronic countermeasures (ECM) environments). These displacement or velocity sensors are expected to perform better then accelerometers for slow moving platforms. The topic will put major emphasis on Size, Weight, Power, and Cost needs for mounted, dismounted and small sensor platform applications.
DESCRIPTION: Sensors should be able to track motion relative to objects such as walls and floors. Potential technologies include: optical field recognition; optical flow field; optical and acoustic range/velocity finders; and floor/ground tracking velocity sensors including Doppler RF and pedometers. Minimizing electrical, acoustic or IR signatures is important.

PHASE I: Phase I would examine current technologies and technology trends to identify opportunities for sensors to measure position or velocity for military operations in an urban environment.

PHASE II: Phase II will entail fabricating prototypes and demonstrating operation in a relevant environment.

PHASE III DUAL USE APPLICATIONS: Phase III will consist of developing a production ready device. Broad application in the civilian community with the current and future application of navigation assist First Responders and to civilian vehicles. Navigation capability during GPS signal outages experiences within buildings, tunnels and underpasses will be maintained.

REFERENCES:

KEYWORDS: Displacement sensor, velocity sensor, position, navigation.


TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PM-Measurement, Electric Power, and Protection

OBJECTIVE: To evaluate the feasibility of applying emerging high risk / high payoff materials, power, and hybrid technologies to the designs of an array of JP-8 fuelled power components and/or sources in the 250 to 2000 Watt range that demonstrate a 20% improvement in power density (~34 W/kg) and a 10 dBA reduction in noise signature (~60 dBA), and that provide a continuous power output for long duration (>4 hours) missions. Potential power source concepts should enable the Army’s Future Combat System network and in doing so complete one of the critical paths that leads to a complete Army Transformation.

DESCRIPTION: Without POWER, the Army’s Future Combat System network – the key to Army Transformation - will fail to operate, jeopardizing mission and soldier safety, in a sustained battlefield environment.

For the last decade, the Army has been taking advantage of R&D breakthroughs and integrating them to create unique C4ISR and Land Warrior platforms that enable the Future Force to see first, understand first, act first, and finish decisively. Yet, platform power requirements have not been properly addressed resulting in platforms that cannot start, stop, and operate at full capacity in various military environments.

The linchpin to achieving a complete Army Transformation and sustaining all elements of the operating forces in theater at all levels of war is POWER.

The power range of interest and tactical need is for 250 to 2000 Watts power sources. Currently there are no high power density power sources that provide this range for long duration missions (> 4 hrs). The objective of this effort is to evaluate emerging power technologies that will allow the Army to develop an array of proof-of-concept power sources that use logistics fuel and that demonstrate a 20% improvement in power density (~34 W/kg), a 10 dBA reduction in noise signature (~60 dBA), and a continuous power output for long duration (> 4 hours) missions.

The approach is to conduct applied research on application of advanced material sciences and of physical sciences in energy conversion, electronics, and signature suppression as they apply to the adaptation of emerging power components and hybrid subsystems, and the advancement of more fuel efficient JP-8 fuelled microturbine and
Stirling systems, alternative alternator topologies based on metamaterials, field programmable hysteretic current mode controllers (advanced power electronics), and high speed opposed piston (HCCI) engine technology for the Future Force. Resulting proof of concept systems shall be low-cost, fuel efficient, environmentally compatible, high power density power sources capable of supporting C4ISR capabilities and silent watch applications, affording auxiliary vehicle power, providing power for soldier battery charging, and enhancing the versatility/deployability of the Future Force.

Resulting power sources will address power needs of first response/expeditionary type missions. Successful results of advanced research will enable the Army to provide power in a range (< 2 kW) where no fueled, high power density power sources are commercially available.

PHASE I: Investigate power solutions based on the use of advanced material sciences and of physical sciences in energy conversion, power electronics, and signature suppression as they apply to the adaptation of emerging power components and hybrid subsystems, and the advancement of more fuel efficient JP-8 fuelled microturbine and Stirling systems, alternative alternator topologies based on metamaterials, field programmable hysteretic current mode controllers (advanced power electronics), and high speed opposed piston (HCCI) engine technology for the Future Force. The selected technology solutions shall be geared at satisfying the power requirements of the FCS in the 250 – 2000 Watt range. Investigation shall identify the strengths and weaknesses of the selected technology path for a defined power range. Recommendations and designs that address areas for improving a defined power component/system or energy source for operation in the tactical battlefield shall be devised. Resulting power sources may be for stand-alone or APU applications in support of the Future Force. Design, develop, and execute an experiment, model, or appropriate study to demonstrate the proposed power source concept and validate feasibility. Provide supporting analysis, which shows feasibility of scaling of the concept design from 250 – 2000 Watts.

PHASE II: Design, develop, and demonstrate a Proof of concept power source based on the Phase I results, and provide an interface design to support the subsequent integration FCS platforms (i.e. C4ISR, Land Warrior, Unmanned Ground Vehicles – robotic).

PHASE III DUAL USE APPLICATIONS: Develop partnerships with individual companies and Platform PMs (such as PM-FSS) for rapid fielding of results into the FCS by FY08.

REFERENCES:

KEYWORDS: Power source to enable Future Combat System network, fuel efficient JP-8 fuelled microturbine and Stirling systems, alternative alternator topologies based on metamaterials, field programmable hysteretic current mode controllers (advanced power electronics), and high speed opposed piston (HCCI) engine technology

A04-099 TITLE: Integrated Biometrics for Handheld and Mobile Devices

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO, Soldier

OBJECTIVE: Utilize biometrics to provide a variety of services to be used on both handheld and mobile (wearable) computing devices for the dismounted warfighter. These services would include: device security, such as authentication; identification for use with user profiles; and situational awareness and alerts based on user identification. User profile and user-based SA dissemination should be capable of operating with both intelligent agents and in a publish/subscribe environment utilizing Linux. Various means of biometrics will be considered such as: iris scanning, voice print, etc. Use of fingerprints is not viable due to widespread use of gloves for personal protection during battle.

DESCRIPTION: The dismounted warfighter in the future will utilize a variety of computing platforms, including a lightweight handheld device, sometimes known as a Personal Digital Assistant (PDA). This PDA will allow the warfighter real-time access to Situational Awareness, operational information and tasking of battlefield resources.
The presence of handheld devices on the battlefield creates the problem of potential capture of these devices. This capture could result in subsequent use by Opposing Forces to obtain critical friendly C2 information greatly compromising friendly forces. There is a need for security that will deny Opposing Forces the use of this PDA. This security must be accomplished within the constraints of ease of use, with little or no impact on the performance of Command and Control (C2) applications running on the PDA. It must allow the use of the PDA by an authorized individual or multiple authorized users. The soldier must be able to employ this device while wearing gloves. Security features desired include: password history tracking, application launch protection, user specific policy settings, enterprise wide policy settings and password policy.

Application of this security technology would benefit Objective Force dismounted warfighters by allowing the user to use the PDA for real-time C2 applications with the confidence that the data contained on the PDA cannot be comprised should the device fall into the hands of the Opposing Force.

The use of security on a PDA presents unique challenges given that it must effectively defeat intrusion by unauthorized users, but not hamper or impede the use of the device by the warfighter on the battlefield. Additionally there must be total confidence that should the PDA fall into the hands of the Opposing Force that security measures would render the device useless. The use of biometrics is one possible means by which to accomplish authentication. One restriction is that it be useable by an individual while wearing gloves. Some potential means to accomplish this multi-layered security include strong encryption of user-selected data, bit-wiping of all data stored on RAM if a preset number of attempts to log in by an unauthorized user is reached, encrypted data transfer and IR port disable. Other innovative concepts are encouraged and will receive equal consideration. Innovative ideas to accomplish the desired level of security are sought with emphasis on a Linux-based environment.

PHASE I: Research state-of-the-art components, subsystems and systems for implementing biometrics on a handheld device to support both security and role-based authentication and profiling. Performed analytical studies and trade-off analysis of the technologies and devices examined. After completing this initial analysis, develop a biometric-based authentication, user profiling, computer security and information dissemination architecture for mobile computing devices, such as handhelds, wearables and other mobile computing devices utilizing biometric means, such as, but not limited to, retina/iris identification, voice print technology or other means.

PHASE II: Implement the biometric authentication, user profiling, computer security and information dissemination architecture designed under Phase I on a prototype system for demonstration and testing by the user community.

PHASE III DUAL USE APPLICATIONS: Transition the biometric system from Phase II to PM, Soldier for use on their systems. Transition technology to commercial marketplace for handheld and mobile computing devices.

REFERENCES:
1) RAND report on biometrics for the Army http://www.rand.org/publications/MR/MR1237/

KEYWORDS: Biometrics, computer security, handheld computing, personal digital assistant, PDA, wearable computers, mobile computing, authentication, retina/iris scanning, voice print

A04-100 TITLE: Information Distribution for Handheld and Mobile Devices

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO, Soldier

OBJECTIVE: Dismounted warrior systems in the future will need to distribute information through self-gathering intelligent agent schemes over ad hoc networks. In today’s ad hoc networking, the network is not optimized for traffic flow for intelligent agents. For example, there may be instances where information may be relayed through a node by means of tunneling when that node will be receiving that same information from a different node in the
network later. This is a redundant transmission of information that both leads to increased latency, as well as network congestion. An optimization tool for managing the information flow of intelligent agents through an ad hoc network is desired.

Application of these techniques would benefit Objective Force dismounted warfighters by maintaining connectivity to squad members and higher echelon computing infrastructure, and enable timely relevant CROP formation, intelligent control of organic sensors, and/or unmanned platforms. The warfighter would be able to see the information quicker (see first, understand first) through both reduced latency from shorter routing schemes and higher throughput allowing more multimedia (video, audio) services from reduced traffic load on the network.

DESCRIPTION: The application of mobile agent technology to tactical network environments provides a key enabler for linking the dismounted warfighter to the computing infrastructure of the Army's Network Centric Warfare concept. This presents technical challenges for optimizing the use of distributed services in such dynamic networking environments.

Emerging Ad Hoc tactical environments that will connect to the GIG present an ever changing topology of mobile computers. Agent enabled distributed systems must adapt dynamically to this ever changing network topology, without a prior knowledge of services, or risk failure, latency, and unnecessary consumption of bandwidth to reach remote computing nodes. Agent applications, such as that under development for the Army Command and Control Handheld (C2HH), utilize tactically focused agents (based upon the Extensible Mobile Agent Architecture (EMAA)). Such applications would benefit from innovative techniques to balance agents' routing with the needs of the application. Innovative techniques are sought to exploit agents' awareness of runtime Ad Hoc topology to produce globally optimized system performance while minimizing bandwidth usage. As a result, agents would alter their workflows to minimize impact from topology changes by dynamically selecting routes and computing hosts to maintain system performance in the presence of network and/or processing bottlenecks.

PHASE I: Research state-of-the-art means to manage routing and paths traversed by intelligent agents operating within an ad-hoc network environment. Perform trade-off analysis and performance metrics to ensure the viability of the information flow management schemes under examination for implementation on mobile computing devices such as handhelds (Personal Digitail Assistants - PDA's) operating on an ad-hoc network. Develop methodology and approach to manage information flow with respect to intelligent agents within common ad hoc networks. Methods should be able to work with various ad hoc routing schemas currently in use. Specific routing methods and intelligent agent approaches will be discussed with the user community during Phase I to determine the best approach.

PHASE II: Develop, and test an information management scheme developed under Phase I for intelligent agents that allows for improved and efficient routing of intelligent agents operating over ad hoc networks utilizing small, mobile computing devices, such as PDA's. Implement and demonstrate this information management scheme on a targeted mobile system based on projected requirements from either the Land Warrior and/or FCS program. The actual target device will be determined by the Government at the start of Phase II.

PHASE III DUAL USE APPLICATIONS: Transition technologies developed to both PM, Soldier and PM, FCS for use on future systems employing both intelligent agents and ad hoc networks. Transition to commercial vendors employing mobile intelligent agent technology for applications such as mobile sales force management and information distribution.

REFERENCES:
1) EMMA used in command and control systems:

KEYWORDS: Intelligent Agents, Ad hoc networks, Handheld computing, PDA, wearable computing, mobile computing, security, collaboration, mobile networks, ad hoc networks, network management, information management
TITLE: Arabic to English Machine Translation System

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Combatant Command Interoperability Program Office (CIPO)

OBJECTIVE: To develop improved technologies leading to a fully automated Windows-based Modern Standard Arabic (MSA) to English Machine Translation (MT) system that will automatically detect and understand spoken Arabic/English of Arabic radio/TV broadcasts with semantic features, idioms, taxonomy and large-scale lexicon to produce an unambiguous high quality accurate translation (preserving the original meaning), with robust syntactic processing algorithms.

a- Many foreign TV and radio broadcasts in Modern Standard Arabic (MSA) such as Al Manar, Al-Alam and Al Jazzera provide the first hand and the latest information about events taking place in areas which the US has a strong military or political interest. However, due to a variety of reasons, US forces have to resort to collecting information through monitoring these foreign broadcasts. These broadcast stations provide invaluable information for Government agencies which are involved in information gathering, monitoring or executing civil administrations, medical assistance, force protection, peace keeping operations, refugee camps, and UN/US sponsored food programs to name a few. As such, there is a need to understand, share, analyze, correlate, locate specific information and retrieve, store and publish information to local US authorities, national and international organizations. The Arabic language has more complex inflectional morphology than other languages and it is lexically more ambiguous. The result is unusually dense translation ambiguities that impede computational analysis, interpretation and translation of spoken subjects in a time-constrained environment. Emerging linguistic formalisms from universities offer increased opportunity for correctly understanding Semitic languages such as Arabic which contain complex morphology and varying dialects.

b- There are no ATEMTS systems in the commercial market as of this date. There are few derivatives of commercially ATEMTS systems available in the market which are designed in prototyped/hard wired form and are aimed specifically to execute the tasks and examples cited here with limited capability. Additionally, there are no interactive commercial ATEMTS software systems tailored to meeting US forces requirements that can fully and satisfactorily meet the Army’s spoken Arabic into English requirement with the high quality of accuracy and independence. Current available systems lack accuracy, modularity, and transparency and at times require a man in the loop to constantly train, upgrade and fine tune the ATEMTS systems for credible use. The Army requires the application of the "next generation ATEMTS software” to address the urgent NLP MT difficulties associated with accurate translation and meaning preservation of spoken Arabic to English language translation. Therefore, basic MT computational analysis R&D is needed (i.e., bilingual Corpus-based MT, Memory based MT, Example Based MT, Statistically based MT and morphological tagging, etc.) to achieve high reliability and broad coverage qualities in a matured MT system.

The objective design will have the basic capabilities to integrate: (1) comprehensive syntactic processing and semantic analysis that takes into account context to disambiguate meaning; (2) thorough and deep morphological analysis; (3) full-scale lexicons, partitioned by domain (e.g., military, medical, computer); and (4) English and Arabic generation understandable by a native speaker of the target language.

PHASE I: Conduct feasibility studies in all areas of ATE-MTS, Corpus-based MT, combination of a linguistic approach with a statistical approach to fine-tune the alignment and enhance processing of bilingual corpora by formulating and proposing highly creative and innovative methodologies in order to improve the fundamental technologies leading to design, development, and demonstration of basic functionalities for a totally integrated and fully automatic functioning MT/ASR/NLP software module. Specifically, the bidder should:

a- Conduct research and studies to improve and enhance NLP speech recognition for adequacy and intelligibility from Arabic to English with 75 to 85 percent accuracy.
b- Conduct research and studies to improve translation between spoken Modern Standard Arabic and English with 75 to 85 percent accuracy using a representative but restricted lexicon.

c- Study and develop a preliminary embedded translation algorithm that assume errors in speech recognition.

d- Develop a preliminary user’s manual.

e- Define comprehensive plans; including detailed engineering specifications, methodology, estimated man-years and requirements for enhancements to make the System a practical commercial-grade software product upon completion of Phase II.

Note 1- The restricted lexicon will cover two areas: 1) Basic usage (the verb to be, go, come, read, look etc), 2) Intelligence gathering including some colloquial Arabic (Arabic English equivalent of “ain’t”, “gonna”)

Note 2- Translation Accuracy: Accuracy is measured by the post edit ratio defined as the total number of words in edited text minus the number of words changed, moved, or deleted, divided by the total number of words after editing.

PHASE II: Phase II would be a continuation of Phase I, with the aim of developing a fully integrated and functioning prototype system of components, which should have dual use market potential. Under Phase II, the bidder will demonstrate capabilities with commercial components. The prototype should be matured enough to attract commercial venture capital for full product release making the prototype into a commercial-grade product, by making enhancements and using the findings of Phase I.

a- Reject duplicated items with 95% accuracy

b- Translate spoken Arabic to English with 85 to 95% accuracy.

PHASE III DUAL USE APPLICATIONS: Commercialization of a fully automated MT system has large market applications. Commercializing capabilities may have functionalities in such fields such as personal, educational, journalism, historical lessons learned and the academic arena and many more. For this Phase, implement the results of Phase I and Phase II, develop, demonstrate and deliver a user friendly working system to perform functionalities with the specific application overlays cited above.

REFERENCES:
Evaluation is recognized as an extremely helpful forcing function in Human Language Technology R&D. The following reports will be helpful.

1) IBM Research Report, BLUE: a Method for Automatic Evaluation of Machine. Translation IBM report # RC22176 (W0109-022) dated September 17, 2001-Copies can be requested from IBM T. J. Watson Research Center ,Center, P. O. Box 218, Yorktown Heights, NY 10598 USA-email: reports@us.ibm.com Donna M. Gates, Carnegie Mellon University, Pittsburgh, USA dng@cs.cmu.edu. Some reports are available on internet at: http://domino.watson.ibm.com/library/CyberDig.nsf/home


3) Computational Linguistics Formalisms for MT: http://wings.buffalo.edu/linguistics/rrg/

4) DARPA’s Babylon Speech to Speech Translation project aimed to develop a limited domain bidirectional speech to speech translation device. http://www.eff.org/Privacy/TIA/babylon.php

5) Arabic- English Speech to Speech translation products;
   http://www.wired.com/news/print/0,1294,58150,00.html
   http://www.aramedia.com


8) Workshop announcement- Computational Approaches to Semitic Languages http://www.cs.um.edu.mt/~mros/WSL/

9) Predicting Intelligibility from Fidelity in MT Evaluation by: John White Litton PRC, 1500 PRC Drive, McLean VA 22102 white_john@prc.com

10) In One Hundred Words or Less by: Florence Reeder MITRE Corporation- 7515 Colshire Drive, McLean, VA, 22102 USA freeder@mitre.org


KEYWORDS: Arabic to English Speech to Text Machine Translation, parallel corpora, Corpus linguistics, translated corpus, corpus alignment, OCR, MT, NLP, Accuracy, fidelity, intelligibility, and evaluation-, diversified forms of data/documents

A04-102 TITLE: Full Color, Flexible, Day/Nighttime Displays for Mobile Battle Command Environments

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO-C3T

OBJECTIVE: The objective of this task is to design, develop, prototype, and demonstrate a full color, flexible, hands free visor and Personal Digital Assistant (PDA) display to increase the operational capability of Commanders in day and nighttime conditions.

DESCRIPTION: Moving tactically, Commanders and soldiers alike require the ability to view maps and graphic representations of any desired terrain, while on foot or in military vehicles. A flexible, hands-free integrated Helmet Mounted Display (HMD) will significantly lighten the soldier’s load, in field environments. A flexible PDA display variant will also provide Commanders with hands-free situational awareness in vehicles, on-the-move. Both display devices will independently augment the Battle Command Construct (BCC), and the Mounted/Dismounted Maneuver Force Operating Capabilities (FOC). Specifically, FOC-03-01 indicates, “Battle Command is a core competency for all Objective Force units, including organic capabilities for collaboration on the move, continuous assessment, and predictive analysis”. Additionally, FOC-05-01 Para (3) indicates, “Provide enhancement that will enable soldiers to conduct dismounted movement with load bearing equipment and load not to exceed 40 pounds, and a goal of 15 pounds as a fighting load”.

The developed flexible displays must have sufficient resolution to show high information content maps. Therefore, an active matrix display screen is necessary. The transparent HMD shall not obstruct the view of the soldier’s external environment, while he/she is attempting to view relevant information displayed on the device during daytime operations. The hands-free PDA display, as part of the Commanders’ uniforms, will provide them with the ability to legibly discern data from their PDA during daytime and nighttime conditions. The PDA shall not give away the Commander’s position or location during such nighttime situations. To avoid visual signature detection at
night, the PDA shall be dimmable to a minimum brightness, and be viewable only through conventional Image Intensification (I2) night vision goggles. The intent is not to develop full color night vision goggles. Instead, an innovation is sought, between the Command and Control (C2) software displayed on the PDA, and the conventional monochrome night vision goggles. Ideally, while the Commander would peer through the goggles, the displayed images from the PDA would appear to be color. The design goals should include combating the halo effect and lower resolution of the night vision goggles, to permit legibility of high-resolution mapping data displayed on the PDA screen. The flexibility of the PDA display will allow Commanders to attach the unit onto their Battle Dress Uniform (BDU), thereby providing hands-free situational awareness, or stow the system in their pocket.

The flexible displays shall have the ability to be read from any viewing angle and, connect to current Army communication devices (i.e. computers), as well as major industry standard interfaces. Lightweight, low power and survivability in an uncontrolled battlefield environment are all important design goals.

PHASE I: The contractor shall design a flexible, transparent helmet mounted visor display, and a night vision compatible PDA display, as described above for use by Army Commanders inside military vehicles, military aircraft, Command Post shelters, or on the ground. The contractor shall also perform a feasibility analysis of the design and demonstrate each device’s capabilities through analysis, simulation, or other means. At a minimum, the analysis shall include: power requirements, size, weight, as well as operational, technical, and nighttime compatibility issues. The contractor shall also develop a test plan during Phase I that will enable comprehensive operational, capability and environmental testing of the device to be conducted in Phase II. Flexible mock-ups of the anticipated displays is requested, as part of the Phase I deliverables.

PHASE II: The contractor will perform prototype demonstrations of the flexible displays per the proposed Phase I system design. Prototype demonstrations will address the issues for use in daytime and nighttime conditions, integrated into a soldier’s helmet and BDU. The flexible displays will be tested per the proposed Phase I test plan.

PHASE III DUAL USE APPLICATIONS: The contractor will install and test the reliability of the prototype flexible displays during actual operational exercises by attaching a prototype to a soldier’s BDU. It is envisioned that similar displays would be desired for homeland defense agencies that use portable computers or flat panel displays (police/fire/rescue). This technology could also be used in the commercial arena as well. Consumers are always looking for smaller and more portable computers that are lightweight and could be viewed at any angle and in the sunlight or at night.

REFERENCES:
5) PC Magazine, 3 SEP 03, “Mobile-Phone Display”: http://www.pcmag.com/article2/0,4149,4149,416922,00.asp
6) PC Magazine, 1 JUL 03, “Plastic Transistors”: http://www.pcmag.com/article2/0,4149,1130810,00.asp
7) PC Magazine, 6 AUG 02, “Press on Displays”: http://www.pcmag.com/article2/0,4149,440475,00.asp

KEYWORDS: Flexible displays, Personal Digital Assistant, Night Vision, situational understanding, battle command, on-the-move

A04-103 TITLE: Handheld Positioning/Navigation System for Urban and Indoor Environments
TECHNOLOGY AREAS: Information Systems, Electronics
OBJECTIVE: The Army requires the ability to locate the position of its platforms in all environments, both for navigation of that platform as well as for position dissemination for situation awareness. The primary source of position in most Army platforms is the Global Positioning System (GPS). GPS signals are not available in most urban and indoor environments and are susceptible to electronic RF interference. In the spring of 2003, the US Army Communications-Electronics Research, Development and Engineering Center (CERDEC) conducted experiments at the request of HQ AMC to investigate the feasibility of the using Loran-C by dismounted soldiers in urban and indoor environments. It was shown that in these environments Loran-C signals could be received by current systems. However, it was found that in these environments the current equipment suffered from interference attributed to power lines, motor generators and fluorescent lights. It was found that the current systems which were originally developed for smooth trajectory platforms such as boats and planes experienced difficulty related to a constantly changing antenna direction when carried by an individual. As Loran-C systems are not rich in accuracy and their signals may not be available deep within buildings, and their signals may not be available in all places of military operation, it's desirable that a system be developed that is capable of also receiving signals from portable beaconing systems and possibly other sources as well.

DESCRIPTION: This topic will develop a prototype positioning system for use by individuals in urban areas. At a minimum the system will be based upon the use of portable locally positioned transmitters and the Loran-C system. It may also make use of other available signal sources to improve positioning accuracy and availability such as GPS, differential GPS, network assisted GPS and information provided to improve Loran accuracy and availability. Goals of the system are to be able to demonstrate in an urban and indoor environment a 1m (95% - horizontal error) positioning accuracy when the system is solely dependent on portable transmitters, 10m accuracy (95% - horizontal error) when the system is solely dependent on Loran-C and will demonstrate the capability to operate in a mixed-signal environment. Demonstrations will be conducted to determine the availability of a position solution in various urban/indoor environments. These demonstrations will evaluate the system's RF penetration capability and resistance to signal multipath against various types of walls (wood, sheetrock, mortar, brick, and reinforced concrete of different varieties) as well as varying the number of walls and distances that the signals can be received.

PHASE I: Define an approach to develop and build a single handheld system and portable beaconing system for operation in the system context described above. A trade study will be conducted to determine the optimal waveform for the portable beaconing system and will take considerations for security, RF wall penetration, the portable beacon's size/weight/power (SWAP), and commonality with the Loran-C waveform.

PHASE II: Develop, build, evaluate and deliver a handheld prototype system and the associated portable RF beaconing systems (this will include delivery of an appropriate number of transmitters as determined in Phase I to support an urban/indoor scenario evaluation).

PHASE III DUAL USE APPLICATIONS: Transition prototype system to production system, qualify system for performance and reliability.

Dual Use Examples: The use of positioning and navigation information is very much prevalent throughout the military and commercial industry. This system will enable positioning for vehicles and individuals positioning within urban and indoor environments where GPS signals are masked. Commercial examples of urban positioning requirements include first responders (fire, police and other rescuers), transportation tracking and guidance (trucks and delivery), construction, house arrest prisoners, and alzheimer patients.

REFERENCES:


KEYWORDS: navigation, positioning, RF ranging, Loran-C

A04-104 TITLE: Co-Channel Interference Mitigation Test Apparatus

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PM Signal Warfare

OBJECTIVE: Develop a ground breaking algorithm and development tools to solve the co-channel interference problem for airborne collectors. Develop this algorithm to operate in an open architecture that will support numerous airborne collectors for Army, Navy and Air Force.

DESCRIPTION: The Airborne collection environment will encounter a large degree of its operations in an environment predominated by co-channel interference. Airborne Signal Intelligence (SIGINT) collectors will need advance algorithms that can be ported to many systems to assure operational success in the co-channel environment. Currently there is no scientifically constructed co-channel interference rejection (CCIR) algorithm and development environment that works effectively in an operational environment. The algorithm development will be performed in a realistic environment on an open system architecture to ensure success and portability. CCIR algorithms vary greatly in their degree of success against different signal classes. This algorithm will be optimized to work against a wide class of signals. Capabilities of the algorithm will include detection, direction finding, and signal copy. The algorithm will be validated in a government-developed environment that has the capability to include both software and hardware-in-the-loop and will ultimately be flight-tested at our Lakehurst flight test activity. Innovation will be required to assure development environment is also realistic. So as part of this effort, we will develop a representative open systems architecture using digital techniques to model the co-channel environment. A scientific understanding and ability to develop potential algorithms and array antenna solutions in a near realistic environment is critical to assuring the success of the Future Combat System (FCS), which will be collecting and processing massive amounts of radio frequency (RF) signal data. The algorithms and development architecture tools will be able to work in a recreated, faithful environment representative of the following characteristics:

- Large to small signal emitters
- Wide class of signal types
- Closely spaced to widely spaced signal sources
- Supportive of a wide variety of antenna array architectures
- Have variable sensitivity capabilities to match the environment encountered

PHASE I: Feasibility study for the basic methodologies and scientific principles required to access CCIR for a demonstration capability including an assessment and report on the preliminary design, algorithm and development tool, capabilities, and limitations. Propose an implementation plan with associated costs and preliminary design.

PHASE II: Assemble and demonstrate an algorithm capable of being evaluated for co-channel interference mitigation. The prototype shall be delivered to the Government. The prototype should demonstrate both wired and
over-the-air modes of operation for at least four co-channel signal inputs to an eight-channel receiver system. The demonstration should show both multiple transmissions and overlapping signals of different types with data logging for scientific assessment of results.

PHASE III DUAL USE APPLICATIONS: The co-channel interference algorithms and development tools could have commercial applications for test and evaluation of multi-channel wireless links, enhanced cell phone cell area usage, and operations of aircraft in a crowded RF environment.

REFERENCES:
1) http://www.fas.org/man/dod-101/army/docs/astmp98/sec3f.htm
2) http://iwce-mrt.com/ar/radio_lmr_systems_military

KEYWORDS: Co-Channel Interference

A04-105 TITLE: An Ontologically-Based Data Fusion Model

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Distributed Common Ground Sensors - Army (PM DCGS-A)

OBJECTIVE: Develop an ontologically-based data fusion model enabling reusability of the ontologies that describe it and with a mathematically demonstrable foundation. Demonstrate and assess the reusability of this model through a set of software tools for building fusion applications. The accuracy of this model will be demonstrated and assessed in a Future Combat System (FCS) application.

DESCRIPTION: The goal of the proposed research is to investigate, develop, and demonstrate a formal data fusion model. This model should provide a formal engineering-analytic basis to the data fusion process. It is currently defined by the Joint Directors of Laboratories (JDL) model, which includes levels 0-4, the human-computer interface and the information input interface. Research and development under this effort will result in a descriptive model of the fusion process, and provide a means for scientific reproducibility in fusion experiments, through the reuse of ontologies and parameters that define the model. The model should be interfaced to the human through an acceptable Situational Awareness model such as the OODA [Observe, Orient, Decide Act] model.

PHASE I: Assess, and report on, the state-of-the-art of practical and theoretical information fusion models, particularly those with an ontological basis. The principal focus will be the development and demonstration of an ontologically-based fusion model for full development in Phase II. This model shall include, for the human-computer interaction, an acceptable Situational Awareness model or paradigm. Particular attention will be given to the level 2 and higher functions in the proposed model. Develop the model in a theoretical and practical sense, demonstrate its validity and ontological basis, and understanding through analysis and testing. Based on this understanding, identify the apparent utility as well as limitations of the model. Identify new approaches (consisting of existing and/or new, techniques, technologies and methods), or extensions/modifications to the state-of-the-art, that could provide a focus for development of an improved model. Provide theoretical and empirical evidence to support the recommended model approaches. Select candidate applications for this model for use in the commercial (dual-use) sector. Publish theoretical results and practical findings.

PHASE II: Develop a prototype model targeted at a small set of elements for the FCS intelligence function. Continue to improve the model based on the recommended approaches found in Phase I, and continued testing. Demonstrate the capability of the model prototype to develop real/realistic systems for information fusion tasks, and the effective analysis of those tasks.

Design a scientifically sound method (metrics, experiment design, etc.) to evaluate the efficiency and operational effectiveness of the prototype to include agreed-upon metrics. Conduct experiments to provide an empirical basis for the evaluation, using an FCS scenario, and interfaced within the I2WD fusion test bed. Developing measures of
effectiveness based on the FCS scenario. Identify promising follow-on work to extend the capabilities of the technology, and to increase its maturity to a level adequate for commercial (dual-use) application. Analyze and report on improvements to the model to allow greater autonomy of operation. Provide copy of final version of software developed, including support software, scenario(s), and tools necessary to demonstrate results.

PHASE III DUAL USE APPLICATIONS: Potential applications include: information/intelligence analysis for government organizations such as the U.S. Coast Guard, the Immigration & Naturalization Service, and the Federal Emergency Management Agency, or data fusion supporting commercial dual use diagnosis in internal medicine.

REFERENCES:
3) Steinberg, A.N., Bowman, C.L. and White, F.E. (1998), "Revision to the JDL data fusion model", Joint NATO/IRIS Conference, Quebec City, October 1998

KEYWORDS: data fusion, ontology

A04-106 TITLE: Integrated Wideband Signal Intelligence (SIGINT) Sensor

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: PM Signals Warfare

OBJECTIVE: Develop a small, man-portable wideband Signal Intelligence (SIGINT) receiver with integrated Global Positioning System (GPS), phase/frequency reference, digitizer, digital drop receivers and inertial navigation unit providing a complete SIGINT sensor in a single unit that will accept radio frequency (RF) inputs and provide outputs to a Local Area Network (LAN).

DESCRIPTION: Although wideband SIGINT receivers are available from numerous sources, some include digital drop receivers or digitizers, they all require other devices to provide SIGINT processing functionality plus other inputs required for SIGINT operations such as GPS, navigation and frequency reference. Presently, systems require multiple chassis and connections that have duplicate functions and components driving up the cost and system size. The main technical challenge here is to develop advanced shielding technology that will permit the integration of multiple digital devices in close proximity to highly sensitive receivers. Present shielding concepts do not meet weight and size for miniature packaging and still address radiated and conducted noise sources. The desire is to have a small, low cost unit that can accept RF and GPS antenna inputs and provide a network connection for outputs without receiver desensitizing. The unit must internally handle the GPS, timing, navigation, digitization and signal processing functions and would provide an embedded personal computer for SIGINT processing (to support direction finding (DF), time difference of arrival (TDOA), signal identification and other functions). This would allow widespread application of the sensor in space and weight constrained environments and in unattended and remote installations. The challenge for this effort is packaging all this equipment in a single Line Replaceable Unit (LRU) while minimizing noise and maintaining the RF signal fidelity to support precision signal measurement functions which require extremely low phase noise and spurs, high selectivity and dynamic range and consistent RF and digital performance over environmental conditions. Existing integrated receivers/digitizers/Digital Drop Receivers often don’t have the performance of dedicated RF tuners, which are used for these functions. Integrating even more functions/components into a single device beyond front end processing such as GPS, navigation, equalization, timing and base band processing while maintaining the required performance of the individual components will require new approaches to component design, integration and noise source shielding and isolation to prevent driving to heavy and large integration methods and higher cost components. This device would enable digitization, processing and navigation at the antenna and would enable the development of robust distributed, multi-channel processing applications in a very small man-portable package presently unattainable with today’s techniques. The developed unit would be used in numerous DoD applications in airborne, ground, manpack and surface applications and also by law enforcement and spectrum monitoring agencies. The device would provide a
versatile and modular signals processing capability when coupled with government and commercial off the shelf software (GOTS/COTS).

Desired features include wide instantaneous bandwidth and frequency coverage, high dynamic range, multiple RF inputs and digital drop receivers, programmable channelization, IQ time tagging and removable memory. Requests for this type of capability is presently ranked number two by CENTCOM to detect Improvised Explosive Devices (IED).

PHASE I: The contractor shall develop an innovative concept and design for the product described in the objective and description above. The contractor shall perform a feasibility analysis of the design and demonstrate its feasibility through analysis, simulation or other means and provide a report to the government.

PHASE II: The contractor will develop, prototype and demonstrate the concept that was developed in phase I. The prototype must demonstrate enhanced shielding performance. The prototype shall be delivered to the government with all documentation.

PHASE III DUAL USE APPLICATION: Develop two units and demonstrate the functionality and capability in the Joint Service/Agency PC Geolocation System (PCGS) testbed supporting the Army, Navy, Federal Communications Commission (FCC), United States Coast Guard (USCG), counter IED Task Force and other government agencies in conjunction with the C4ISR On-The Move Demo at Communications-Electronics Research, Development and Engineering Command (CERDEC), Ft. Monmouth. Deliver to the government mature prototypes that include a graphical user interface (GUI) and application programming interface (API) for incorporating third party applications. The developed unit would be a direct replacement for equipment used in the Personal Computer Geolocation System (PCGS) system being developed by CERDEC for Army, FCC, USCG and homeland defense applications and could also be used in numerous other applications requiring a high performance wideband receiver. The FCC has expressed interest in such a device.

REFERENCES:

KEYWORDS: Wideband receiver, Software Defined Receiver, SIGINT, TDOA, AOA, GPS, INS

A04-107 TITLE: JAVA Raw Socket and Network and Transportation Protocol Layer Application Programming Interface (API)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Information Warfare

OBJECTIVE: Develop a new Java Application Programming Interface (API) that will facilitate the creation of RAW Sockets thus allowing the low level control to networking protocol mechanisms.

DESCRIPTION: The Java language provides a very versatile programming environment with high priority placed on ease of use and security. Both of these features have prevented the implementation of a Raw Socket API package from being developed by Sun. It is believed that such a package would degrade the current Java security model and may be difficult to implement in a non-operating system (OS) dependent fashion. The implementation of such a library, however, would greatly expand the current capabilities of the Java language as related to network communications. Additionally, the development of separate Internet Protocol (IP), Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) classes to support these common communication protocols would allow
a programmer the ability of using Java for low level networking projects while maintaining OS independence
(something that is currently not achievable with the language). These augmentations to the language, would allow
Java to be used as lower level programming languages such as C/C++. Access to lower layers of the protocol stack
will allow network development capabilities currently unachievable in Java.

PHASE I: Research the ability and level of effort required to implement a Java RAW sockets API while maintaining
the language’s intrinsic OS independence and security model to the greatest extent possible. The completion of this
phase should result in a detailed report as to the feasibility and repercussions of developing this new Java capability
and possibly a proof of concept program that demonstrates the potential and achievability of this new API.

PHASE II: Develop a Java Raw Socket API that will allow for the creation of RAW sockets bound to the Ethernet
interface present on the host system. Furthermore, this basic Raw Socket API should be extended to allow for
higher level networking protocol stack access levels. This will include the creation of IPsocket, TCPsocket and
UDPsoket API’s along with the related IP, TCP and UDP header structures. The completion of this phase should
result in the integration of this new APIs into the latest Java API (1.4.2 as of the writing of this document) along
with all relevant documentation. In addition, a sample application, which demonstrates the usage of this new APIs
should also be provided.

PHASE III DUAL USE APPLICATIONS: The completion of this phase would result in a mature technology,
which could be successfully applied to both military and commercial applications. Such applications could include
computer Network Monitoring and Intrusion detection software, or proprietary network communication
mechanism in support of military or proprietary networking systems.

REFERENCES:
1) http://java.sun.com

KEYWORDS: Java, API, sockets, networking

A04-108 TITILE: Advanced Visualization Support of Higher-Level Fusion Processes

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Distributed Common Ground System

OBJECTIVE: Improve the level 2 data fusion process, by providing visualization assistance. This should result in a
joint visualization-level 2 synergy which aids the level 2 fusion through visualization. A visualization-assisted data
fusion model and associated software should be developed that includes an interface to an acceptable Situational
Awareness model. Develop feasibility models and prototype which will be demonstrated for effectiveness through a
set of tests within a Future Combat System (FCS) application.

DESCRIPTION: The goal of the project is to investigate, develop a model, program, and demonstrate visualization
assistance at level 2 data fusion. Data fusion is defined as: “a process dealing with the association, correlation, and
combination of data and information from single and multiple sources to achieve refined position and identity
estimates, and complete and timely assessments of situations and threats, and their significance. The process is
characterized by continuous refinements of its estimates and assessments, and the evaluation of the need for
additional sources, or modification of the process itself, to achieve improved results” Level 2 fusion is defined as:
estimation and prediction of relations among entities, to include force structure and cross force relations,
communications and perceptual influences, physical context, etc” The proposed visualization assisted fusion model
should have some formal basis. The proposed approach could include novel data fusion models, other than the
standard JDL model. Examples of possible approaches are: The human-computer interface sub-function within the
data fusion model where higher-level visualization assistance occurs; visualization of the entire fusion process;
relevant fusion sub-processes. The research and development under this effort should result in a more descriptive
model of the synergy between visualization and level 2 fusion process, provide some basis for improvements in
the level 2 fusion, and provide for scientific reproducibility in fusion-based experiments using the proposed model.
PHASE I: Assess, analyze, and report on synergistic fusion-visualization methods, models, and techniques, particularly those visualization processes which can aid and improve the level 2 fusion process. Propose a visualization-assisted data fusion model, and provide an analytical and/or theoretical basis for the model. Identify the utility and limitations of the model. Provide theoretical and empirical evidence to support the different model approaches.

PHASE II: Based on approaches provided from PHASE I, prototype and demonstrate the efficiency and effectiveness of the model. Conduct prototype experiments for a model evaluation. Identify new approaches (consisting of existing and/or new, techniques, technologies and methods), or extensions/modifications to the state-of-the-art, that could provide for development of an improved version of the visualization-assisted data fusion model and the prototype. Provide copy of final version of any software developed under this effort, including support hardware and software, scenario(s), and tools as necessary.

PHASE III DUAL USE APPLICATIONS: Applications include: Information/intelligence analysis for government agencies such as the U.S. Coast Guard, the Immigration & Naturalization Service (INS), and the Federal Emergency Management Agency, or data fusion supporting diagnosis in internal medicine. Demonstrate the capability of the model and prototype to handle real/realistic FCS information fusion problems.

REFERENCES:

KEYWORDS: data fusion, information visualization

A04-109 TITLE: Small Arms Fire and Alternative Missile Launch Detection

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM AES - Aviation Electronic Systems

OBJECTIVE: Develop viable countermeasures (CMs) against snipers using small arms fire (SAF), especially rocket propelled grenades (RPGs), and missiles. This will require the development of alternative SAF/missile launch detection techniques that use affordable technologies. The desired goal is for field implementation via one of the following avenues: the engineering design of a new stand-alone system or modification to an existing or developmental survivability system such as the Integrated Army Active Protection System (IAAPS).

DESCRIPTION: SAF, especially from RPGs and snipers, are an inadequately addressed issue in the survivability community. Resources have previously been expended to address the more lethal threats, such as anti-tank guided missiles (ATGMs) and surface to air missiles (SAMs). SAF are difficult to CM due to the fact that they do not have sophisticated guidance systems that can be exploited to advantage. Past techniques have relied on legacy approaches of laying fire on the source or seeking the protection of cover or armor. New techniques are needed when these approaches are not available or appropriate such as techniques to pre-detonate fused rounds. One technique is to detect fire initiation and intercept these rounds in flight, either by another missile/round or by directed energy. Another technique could involve the emplacement of a lightweight physical barrier at a standoff distance from the protection area to induce pre-detonation of the incoming round. Also, current production ultraviolet (UV) missile warning systems are background limited and therefore have limited range. Alternative technologies, such as cooled IR focal plane arrays (FPAs) are expensive to produce and maintain. More affordable
missile warning technologies must be developed to make missile warning available to all military platforms that require it. Systems for implementing these techniques must be developed and fielded.

PHASE I: Research the techniques proposed in the past for the development of detection (electro-optical techniques involving infrared, visible and ultraviolet (EO/IR/VIS/UV) radiation) and CM systems for the SAF/missile threat. Develop additional ideas for SAF/missile detection and CM. Perform an analysis of the techniques. Determine the expected effectiveness of the techniques examined for both clear range conditions and typical battlefield conditions (including smoke, weapons fire and munitions detonation flash, etc.) in all weather conditions. Research the availability of component systems, both US military and commercial, and generate a basic design of a functional detection and CM system. Determine the basic system requirements including an estimate of system weight, size, power consumption, and potential cost for the components of a demonstration CM system. Develop the system specification. Model and evaluate the technique to accurately determine its anticipated effectiveness. The US Army sponsor will select a system for phase II based on this analysis.

PHASE II: Engineer, develop, test, demonstrate and deliver a brassboard prototype model of the system to I2WD. Provide to the government a hardware demonstration of the system function and the proposed technology. Design, fabrication, characterization and test of the prototype shall be conducted by the contractor.

PHASE III DUAL USE APPLICATIONS: The development and engineering of an advanced development model of this system will serve DOD and commercial ventures by demonstrating viable and cost effective SAF/missile detection and CM techniques for both military and commercial vehicles/aircraft. It will be valuable to the Homeland Defense initiative and law enforcement for self-protection of aircraft from the terrorist SAF/missile threats.

REFERENCES:
1) http://www.homelanddefensejournal.com/scoop_dircm.htm
2) http://www.cnn.com/TRANSCRIPTS/0311/17/ltm.20.html
4) http://www.mbda.net/site/FO/scripts/siteFO_contenu.php?lang=EN&noeu_id=132

KEYWORDS: small arms fire, rocket propelled grenades, countermeasures, integrated army active protection system, infrared missile detection, infrared countermeasures

A04-110 TITLE: Wideband Collection

TECHNOLOGY AREAS: Chemical/Bio Defense, Information Systems, Materials/Processes, Electronics

ACQUISITION PROGRAM: PM Signal Warfare

OBJECTIVE: Design and build a wideband collection system that will cover a wide variety of signal collection requirements. The objective is to have a cost of under $5000 per unit at delivery and to cover a frequency range of 20 MHz to 18GHz (with 2MHz to 40 GHz desired). The challenge in this effort is to develop a low-cost, low weight and power, and ruggedized wideband collection system to address these needs.

DESCRIPTION: The Army has a requirement to have a small, portable low cost, system for radio frequency (RF) environmental surveys and special testing which cannot be accommodated with currently available hardware. Currently available commercial receivers, test equipment, and data storage devices are overly large, highly expensive, and not easily transportable or employable in unimproved field locations or aircraft. The envisioned system will contain tuners, receivers, processors, recorders, and antennas, and be transportable in transit cases, and ideally, be capable of being mounted in an aircraft using organic antennas. The system will be capable of recording RF spectra including pulsed, continuous wave (CW), and commonly modulated signals over the HF through MMW range (desired.) The data should be stored as digital data for off board processing. The overall size will not exceed two cases, each one of which cannot exceed 65 lbs. The equipment can be operated stand-alone or be removable for insertion into standard 19" racks. All interconnecting cabling is to be supplied. Equipment should be capable of
operation off prime power of 28 VDC or 120 VAC 50-400 Hz. Total power consumption should not exceed 100 watts per case.

PHASE I: Develop architectural models, prototype system design, and establish expected system performance and perform trade-off analysis and architecture recommendations using simulation. Provide a cost estimate and schedule for implementation of the selected architecture as a deliverable prototype.

PHASE II: Using the design from phase 1, build a prototype and perform testing to validate the accuracy of the design against the requirements. Deliver the prototype to I2WD. A study for downsizing the prototype for commercial sales with cost and schedule included, shall also be provided. A field demonstration of the prototype shall be performed.

PHASE III DUAL USE APPLICATIONS: Potential commercial (dual-use) applications include the FCC for monitoring non-authorized emitters in their area of interest, commercial radar (US COAST GUARD) and communications companies for monitoring in-band and out-of-band signal emissions from their and other vendors equipment in the field.

REFERENCES:
1) http://www.tcibr.com/PDFs/901as.pdf
2) http://www.erg.sri.com/telecomm/antenna.html

KEYWORDS: Wideband, survey

A04-111 TITLE: Commercial Radio Based Identification

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

ACQUISITION PROGRAM: PM Target Identification and Meteorological Sensors (TIMS)

OBJECTIVE: The objective of this effort is to develop an innovative interoperable civilian architecture for a Commercial Radio Based Combat Identification (RBCI) System to reduce fratricide for non-combatants and neutrals on the battlefield. This will be accomplished by a software modification to small, commercial available radio with GPS.

DESCRIPTION: Fratricide is a critical issue today for the armed forces. The issue is being addressed through the Coalition Combat Identification (CCID) Advanced Concept Technology Demonstration (ACTD). The CCID ACTD is researching and developing several technologies that will reduce military fratricide incidents for the Air-to-Ground and Ground-to-Ground mission areas. Radio Based Combat Identification (RBCI) is one of these technologies. Simply put, RBCI is a software modification to existing military hardware that allows a user to interrogate and receive responses on a radio. The CCID ACTD is modifying the Army’s SINCGARS ASIP radio. It will only be used by military personnel. Currently, there is no way to provide fratricide protection to noncombatants and neutrals. This topic will provide that capability, as well as a useful service to civilian emergency and law enforcement agencies. The topic will investigate the feasibility of an RBCI like capability being developed as a standard feature for GPS equipped, small commercially available radios. It can be used by homeland defense, critical personnel/contractors on the battlefield, civilian emergency and law enforcement agencies. It will be applicable and interoperable to the future force via the Joint Tactical Radio System (JTRS).

The system must interface with a commercial GPS receiver for position and be interoperable with various civilian radio vendors. The system will work by broadcasting a GPS based area of interest that all other similarly equipped radios will be able to receive. If they are at this location, they are required to respond back with their identification and GPS location. This will allow for the military to interrogate civilian radios via the commercial RBCI system. It will also allow civilian emergency and law enforcement agencies to have an interoperable way of determining who is where at an emergency site. This Situational Awareness can then be collected to aid the command and control of a
site. The purpose of this effort is to develop an innovative interoperable civilian architecture for a Commercial Radio Based Combat Identification System. This topic will address practical implementation aspects of physical integration, interoperability, and the concept of operation (CONOPS). The commercial RBCI's capability to interrogate affectively, in order to deter fratricides from air attacks, will be investigated by the contractor.

PHASE I: The contractor shall develop an innovative concept for a Commercial Radio Based Combat Identification System. The contractor shall perform a feasibility analysis of the design and demonstrate its feasibility through analysis, simulation, or other means. This analysis shall include, but not be limited to: size, weight, power, frequency and interoperability, operational, security and other pertinent issues.

PHASE II: The contractor will develop, prototype and demonstrate the concept that was developed in Phase I. The contractor shall construct a software model to predict and analyze the detailed performance of the system. The contractor shall deliver 10 prototypes of the concept developed in Phase I. The contractor shall demonstrate the system and compare the measured performance against expected performance values resulting from the phase I modeling efforts. The contractor shall develop a draft national standard for the concept.

PHASE III DUAL USE APPLICATIONS: Technologies for friendly identification have a wide variety of commercial applications. This could be used for law enforcement, homeland security, and emergency response, firefighting, and border patrols. This system could provide a civilian authority the ability to scan/interrogate an area to determine if any emergency personnel are present. Many commercial systems require precision tracking of large assets throughout the country. General aviation could also use this system.

REFERENCES:
4) Radio Based Combat Identification (RBCI), September 2003, CISC 2003, Russell Ruppe.

KEYWORDS: Combat Identification, Radio, GPS, situational awareness, identification, Fratricide
standoff applications, which are often composed of fairly extensive antenna arrays and large form factors. These sensor types have been under utilized for shorter range applications however, where they have the potential to achieve longer detection ranges than other sensor types. The biggest impediments to the use of MTI technology are size and cost. However, with advancements in such technologies as Radio Frequency Micro Electro-Mechanical Systems (RF MEMS), Field Programmable Gate Arrays (FPGA), Analog/Digital (A/D) converters and dielectrics, small form factors for short-range systems have become increasingly practical. The objective of this SBIR is to design and develop an MTI sensor, capable of 360-degree detection of moving dismounted troops, at an objective weight of under 2 lbs. For both UAV and UGS applications the objective detection distance is 3km for targets in desert terrain under windless conditions and near-zero platform speed. This technology will provide operational utility to both UGS and OAV applications. From an OAV perspective, the radar will provide a lightweight detection and cueing device. It will accurately cue narrow field of view sensors, such as EO/IR imaging systems, to those specific areas that have activity, thereby providing a persistent early warning and surveillance capability, while minimizing the operator's workload. For UGS, the sensor will play a similar role as for an OAV with the exception that it will be limited by line-of-site constraints. The technology, however, will still have an extended detection range over legacy unattended ground sensors; thereby increasing UGS detection range and cueing appropriate imaging sensors.

PHASE I: Investigate, analyze and present an innovative design for a lightweight, low cost, MTI radar. Modeling and simulation should be used to the maximum extent possible to demonstrate performance predictions of the design solution. The offeror shall provide the following in a final phase one report:

Detailed description of the methods used

Assumptions made (e.g clutter characteristics, target characteristics, environmental losses)

System Conceptual Design Data (including design trades)

Performance calculations/predictions

PHASE II: Design and develop a prototype, and provide a proof of principle demonstration, based on the conceptual design from Phase I. In this phase, the system shall be demonstrated at tower and ground level to simulate the environment and performance for OAV and UGS applications. The prototype system shall be delivered to the Government. The final report shall explain the approach, implementation and results of the overall effort. The proof-of-principle demonstration shall be provided at the conclusion of this phase.

PHASE III DUAL USE APPLICATIONS: The lightweight MTI radar will find widespread applications in law enforcement, homeland defense and commercial site security. In this phase the prototype will be upgraded, and a thorough test and evaluation will be conducted, against scenarios applicable to FCS, law enforcement, homeland defense and commercial site security. Prospective installation designs for both an OAV and UGS implementation shall be developed. The design shall be fully documented to include all drawings and documentation required to maintain/modify the system delivered to the government.

REFERENCES:
1) Future Combat Systems (FCS) Operational Requirements Definition - 22 Jan 03; TRADOC Pam 525-66.

KEYWORDS: Radar, Moving Target Indicator, MTI, GMTI, OAV, UGS, Sensor

A04-113 TITLE: Wireless Local Area Network (LAN) Based Surveillance System

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PM Signal Warfare
OBJECTIVE: Demonstrate a prototype radio frequency (RF) signal acquisition and sensor system based on a commercial ultra-wideband (UWB) wireless local area network (W-LAN).

DESCRIPTION: The Army has a requirement for airborne tactical surveillance and reconnaissance capabilities. The size and capacity of Army aircraft has always been a major factor in system design due to weight and space requirements. Historically, new systems have been designed every few years to take advantage of the latest trends in micro-electronics to reduce the size and increase the performance of the systems. One way to reduce the impact of payload space and weight requirements is to eliminate the interconnecting cables between the boxes. This could never have been possible until now, with the recent advent of potential wireless LAN based (wide band) capabilities. However, it is unclear to what extent the use of W-LAN technology is compatible with the RF signal acquisition mission. That is, can the W-LAN RF signals be managed suitably so as not to interfere with any antennas/receivers/tuners/digitizers in the RF sensor system.

PHASE I: Selection of best technical approach to satisfy the requirements. Validate concept through technical analysis. Perform requirements analysis for best application of Wireless LAN Based technology to Army airborne Reconnaissance Surveillance Targeting & Assessment (RSTA) systems. Provide cost and schedule estimate for implementation.

PHASE II: Design the selected Wireless LAN Based applications. Implement the design in a prototype and perform testing to validate the accuracy of the design against the requirements. Deliver prototype to I2WD.

PHASE III DUAL USE APPLICATIONS: Example of potential commercial (dual-use) applications include, usage of the Wireless LAN Based Capabilities in Homeland Defense missions both military and civilian, usage in commercial airports to interconnect subsystems in a mobile environment to monitor the perimeter of the airport facility.

REFERENCES:
1) http://www.spectrum.ieee.org/WEBONLY/publicfeature/sep03/uw.html

KEYWORDS: Ultra-wideband

A04-114 TITLE: Small, Low Cost, Long Wave Infrared (8.5-12 Micron) Semiconductor Laser for Military Platform and Perimeter Protection, Free Space Communications and Chemical Sensing

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

ACQUISITION PROGRAM: PM Aviation Electronic Systems (AES)

OBJECTIVE: Develop a small, low cost, innovative semiconductor laser with a continuous wave (CW) output of approximately 1/2 Watt (W), in the 8.5 – 12 micron region, while operating at room temperature. Design a cost effective thermal controller e.g. a Thermo-Electric or Sterling cooler system with an appropriate heat sink to maintain an efficient laser operating temperature.

DESCRIPTION: When in-use, the semiconductor laser will operate under pulsed conditions at a 25% duty cycle, with about a half watt of average power. Since laser efficiency often increases dramatically at reduced temperatures, such operation is acceptable as a means of reducing thermal controller costs. Since thermal stabilization equipment costs vary widely, careful temperature controller design including the laser heat sink is required. Thermal controller expenses will be truly critical to achieving an affordable total system cost. For quantities of 500, system costs without this controller are anticipated to be under $2000, while with the temperature controller system costs are targeted at about $5000. It is anticipated that the total package size will be about 100 cubic inches. Unlike typical Optical Parametric Oscillaor (OPO) based infra-red countermeasure lasers, semiconductor lasers can be operated at giga-Hertz wavelengths and generate highly variable pulse patterns with potentially important application to both countermeasure and laser communications. Atmospheric transmission through the proper windows in the 8 ½ to 12 micron wavelength region is relatively high and so it is especially favorable to laser communications. The ability of
the semiconductor laser designer to control the specific emission wavelength can be critical to realizing high atmospheric transmission and so is considered important. Molecular Beam Epitaxy (MBE) is typically used to manufacture these devices. Hundreds of tiny lasers can typically be cut from an MBE wafer. Such revolutionary technologies are sought to improve affordability, size and pulse repetition frequency (PRF) of lasers suitable for infra-red counter-measure (IRCM) systems, perimeter protection and laser communications. Today, the high cost of the lasers (including life cycle costs) is a large element in the overall cost of the IRCM system, currently limiting the number of systems that can be deployed. Additionally, chemical sensing requires the use of laser lines appropriate to the chemical species sought. For this and other reasons a semiconductor laser allowing determination of the lasing wavelength at the time of growth is required. The freedom to design the emission wavelength is also effectively a counter-countermeasure, preventing the enemy from notching out the specific wavelengths usually associated with certain lasers.

PHASE I: A study will be conducted of the different semiconductor laser technologies to determine the most promising candidates for emission in the 8.5 to 12 micron region. Since temperature stabilization will be required and since cooler costs vary widely careful temperature controller design is also required. It will be critical to achieving an affordable total system cost. At the end of phase one, the architecture and materials of the semiconductor laser will be specified along with an affordable temperature controller design.

PHASE II: Develop, test and deliver to I2WD a prototype laser including temperature controller, providing full-scale hardware demonstration of the proposed technology. Design, construction, characterization and test of the prototype are to be conducted by the contractor.

PHASE III DUAL USE APPLICATIONS: This laser would have application to the commercial world, particularly for homeland as well as military security. Chemical sensing and platform protection would be two such applications. Free space communications offers another dual use enabling covert communications for both military and business applications.

REFERENCES:

KEYWORDS: Long Wave, Infrared laser diode, free space communications, chemical sensing, infrared countermeasures, IRCM

TITLE: Mobile Sensor Systems for Intelligence Collection Using Doppler Shifting of Existing Communication Technology

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM RUS (PEO IEW&S)

OBJECTIVE: To investigate the feasibility of personnel detection sensors that can detect vital signs of personnel through the Doppler shift induced on existing wireless communication signals.

DESCRIPTION: The Army has a need for Sense Through The Wall (STTW) capabilities to detect personnel. Research conducted by Boric-Lubecke & Lubecke has shown that existing wireless communication technologies, like 802.11, can allow one to detect the vital signs of a target through Doppler shifting of the communication signal. This technology will help overcome a shortfall of current STTW systems, which is, the poor detection of stationary personnel. By detecting these minute Doppler shifts induced by ones vital signs, it will allow users to detect personnel that are completely stationary more effectively. This personnel detection technique also has an extremely
low probability of intercept since the signals used are in everyday communications. Size, weight, ability to detect a wide range of threats, and ability to sense through light construction materials (drywall) are also of interest for this topic. This is a key element for the Future Combat System (FCS) and is depicted in the FCS Operation Requirements Document (ORD). Developing these technology would directly tie into Sense Through the Wall (STTW) Science & Technology Objective (STO) for detecting personnel, which has been endorsed by PM RUS, PM Soldier, PM Sensors and Lasers, Objective Force Warrior, and TRADOC. In addition, these technologies can be used as an unattended ground sensor for programs such as Silent Warrior as the technology may prove to be an inexpensive personnel detection sensor.

PHASE I: Investigate the ability to detect vital signs through the Doppler shifting of communication technologies. Phase I shall act as a technical feasibility study.

PHASE II: Upon a successful technical feasibility study, the contractor shall develop a prototype system for demonstration of capabilities and deliver it to the government with all system design documentation.

PHASE III DUAL USE APPLICATIONS: Transition of this SBIR into Phase III will consist of transition into the Army FCS program, PM RUS, PM Soldier and possible commercial programs for homeland security and first responder applications. Prototypes will be developed for field-testing, testing at I2WD and at the Dismounted Battlespace Battle Lab field test facility. The ability for the system to operate on the move, both handheld and vehicle mounted, will be evaluated at this time. Transition planning to the FCS will occur during this phase. The transition potential to military and commercial usage is considered very high.

REFERENCES:
1) FCS ORD, 14 April 2003, UAMBL, Ft. Knox, KY.
2) Amy D. Droitcour; O. Boric-Lubecke; V. M. Lubecke; J. Lin; G. T. A. Kovacs; Range Correlation Effect on ISM Band I/Q CMOS Radar for Non-Contact Vital Signs Sensing, IEEE IMS2003 International Microwave Symposium Proceedings

KEYWORDS: personnel, detection, wireless, autonomous, FCS, size, weight, power, handheld, vehicle, on the move, Sense Through The Wall, STTW, sensors

A04-116 TITLE: Passive Low Light Level Solid State Silicon Imaging Camera Development

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

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

DESCRIPTION: Current image intensifier (I2) goggle technology for man-portable applications is bulky in size and weight and does not lend itself to be fused with other solid state sensors such as SWIR, MWIR and LWIR. Conventional silicon CCDs and CMOS imagers are not capable of passive low light level performance due to high dark current and high readout noise limitations. For passive low light level imaging, the signal must be maximized and noise minimized. CCDs for astronomy applications have been shown to have low light level performance capability by cooling to reduce dark current and by operating at a much slower frame rate which effectively maximize the integration time and reducing the readout noise. Recent “ImpactIonization” CCDs developments potentially could provide low light level performance at normal video frame rates however it is unclear if this technology is suitable for man-portable applications due to the cooling requirement to reduce dark current and to increase “impact ionization” gain. This topic seeks to develop a low cost, low power with no to minimum cooling required, man-portable solid state silicon sensor/imager operating a normal video rates to replace the current I2 goggle technology.
To achieve performance comparable to Gen III I2 goggle technology, the solid state silicon sensor/imager should be of 1280x1040 SVGA format (minimum) or HDTV 1920x1080 (desired), 12 um pitch or less, 30 Hz operation minimum with 60Hz operation desired, 40 degree FOV optics, and with Signal to Noise (SNR) performance of >25 at sensor/FPA illumination levels of 1 E-05 footcandles.

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

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

PHASE III: The commercialization of this technology is expected to provide low cost, high performance low light level imagers for potential uses in variety of commercial applications including transportation, security/law enforcement, medical imaging, border patrol, homeland security as well as military applications such as night vision devices.

REFERENCES:

KEYWORDS: Low Light Level, image intensifier, CMOS, CCDs.
shall include imagery taken from the camera to be delivered showing detection and flight of an RPG (ex dummy on a test range) at a distance of no less than 250 meters from the camera, such imagery to be delivered, along with the camera to the Government, on a video tape or CD or DVD.

PHASE III: Dual use including threat warning to commercial aircraft.

KEYWORDS: Electro-optic, uncooled, detector array, midwave infrared, bolometer.

A04-118 TITLE: Acoustic Landmine Detection

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM-Close Combat Systems

OBJECTIVE: Develop technology for seismic/acoustic confirmation sensor for detection of on-route buried land mines.

DESCRIPTION: The Army desires improvements in its ability to detect land mines from a moving platform using acoustic and seismic waves. Proposals related to excitation for optimal wave propagation and sensors to detect the ground vibration are requested. The desire is to develop excitation sources that preferentially excite the ground in a target area of interest in front of the platform. Robust sensors to detect the ground vibration in the target area are also required.

Preference will be given to excitation sources that do not contact the ground, but other unique solutions will also be considered. The target region for excitation ranges from 0-8 m in front of the platform. The sources should maximize energy in this region of ground to create large amplitude displacements. However, many sensors are adversely affected by structure born vibration and acoustic noise. Thus, the excitation source should minimize structural excitation of the platform and minimize unwanted air acoustic coupling with the sensors.

In conjunction, a displacement, velocity, or acceleration sensing system to measure the excited ground in front of vehicle is needed. Non-contacting sensors are preferred that are insensitive to platform structural vibration and airborne noise. Furthermore the sensors need to be linear, low noise, possess a large dynamic range (velocities as small as 1 micrometer/s at 100 Hz), be robust for fieldwork, and tolerant of environmental conditions. The sensors must be able to provide time series data for multiple spatial locations on the ground. Suggestions include Doppler vibrometers (perhaps with fiber optic launches), ground displacement sensors, microphones, and other unique transducers.

The effort should be planned with the goal of demonstrating technologies for detection with a near 1.0 probability of detection and less than 0.01 false-alarms in a 1m x 1m square scanned in 20 seconds. Preference will be given to equipment that is capable of acquiring data while moving forward. The landmines will range in size from 4.5 cm to 38 cm in diameter or width. Burial depths can vary from surface laid to 20 cm below the ground surface. Size, weight and power consumption are important factors. Proposals should address the development of hardware and field exercises to ascertain mine detection capability.

Proposals that address excitation without sensing will be considered, provided that they can be shown to have minimal adverse effect on existing sensing technologies. Likewise sensing systems with low noise floors and extreme tolerance to acoustic radiation and structure born vibration will be considered. Preference will be given to systems that integrate both excitation and sensing in a cohesive manner.

PHASE I: This proof of feasibility phase will focus on laboratory and limited field investigation of the mine detection technique(s) as a potential candidate for application as a tactical mine detection system. Phase I will include a demonstration to experimentally confirm/verify the lab results and analyses by utilizing a variety of mines and surrogate mines.
PHASE II: The purpose of this phase is to design and fabricate hardware and use it experimentally to confirm/verify the detection capability under varied conditions. The excitation will be evaluated based on absolute amplitude of excitation within a target region and relative level of unwanted excitation to the excitation in this target region. The sensing system will be evaluated based on sensitivity, dynamic range, noise floor, and noise isolation. The combined system will be field evaluated in mine detection tasks. Data collections and tests at Army test sites are strongly encouraged. Practical application of the technology, including proposed host-platform integration, will be investigated. Estimates, with supporting data, will be made of size, weight, power requirements, speed, probability of detection, false-alarms and positional accuracy.

PHASE III DUAL USE APPLICATIONS: This technology has numerous applications in the Army, Navy, and humanitarian demining areas as well as counter terrorism. This tool could be utilized either in a joint mode with neutralization techniques or independently.

REFERENCES:
1) A host of information regarding the current state-of-the-art in mine detection can be obtained in the Journal of the Acoustical Society of America, as well as the following conferences: SPIE Defense and Security Symposium (formerly AeroSense), Detection and Remediation Technologies for Mine and Minelike Targets Session in Orlando, FL; Military Sensing Symposia; Mine Warfare Conference; and UXO Detection and Remediation Conference.

KEYWORDS: acoustic, mine detection, sensing, seismic, countermine

A04-119  TITLE: High Performance Longwave Infrared (LWIR) HgCdTe on Silicon

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Demonstrate a process, based on molecular beam epitaxy, for fabricating high performance LWIR photodiode arrays with a format of at least 256 x 256 x 30 microns on Si wafers.

DESCRIPTION: All military infrared imaging systems capable of multi spectral detection contain a focal plane array (FPA) fabricated from mercury cadmium telluride (HgCdTe). An example of such a system is the Army’s 3rd generation FLIR, currently in development to provide the large standoff distances required for FCS. HgCdTe is made available in the form of thin epitaxial layers deposited by a process known as molecular beam epitaxy (MBE). The benchmark industrial process for fabricating HgCdTe FPAs requires the use of a cadmium zinc telluride (CdZnTe) substrate wafer. Although MBE FPAs fabricated by this process exhibit BLIP performance throughout the spectral regions of interest to the military, the fact that the CdZnTe wafers are expensive and available only from a single source (Japan) makes it imperative that DoD seek an alternative to these wafers.

Silicon wafers offer an attractive alternative and DoD has in the past sponsored the development of MBE of HgCdTe on Si. The current status of this technology is that performance of SWIR and MWIR FPAs made on Si is comparable to that of arrays made on CdZnTe. Unfortunately, a barrier problem has been encountered in the fabrication of LWIR FPAs on Si. A high number of defects, originating at the substrate/epilayer interface, thread into the epilayer and reduce the sensitivity of diodes to an unacceptable level.

Recently, in III-V materials’ systems, a passivation of the electrical effects of existing dislocations by exposure to certain atomic species has been demonstrated. No such demonstration has taken place for II-VI materials.

The goal of the proposed program is to develop novel techniques for neutralizing or eliminating diode-killing dislocation defects in HgCdTe epilayers.

PHASE I: Show feasibility of a process for neutralizing or eliminating threading dislocations in MBE LWIR HgCdTe on Si.

PHASE II: Further optimize the process demonstrated during Phase I. Minimize the dislocation density in buffer layers or in active layers, using an upper benchmark limit of 1E5. Fabricate test diodes using the improved mercury
cadmium telluride. Evaluate the electro-optical characteristics of these diodes. Measurements should include minority carrier lifetime. Use these test results to further iterate the dislocation-reduction mechanism. Fabricate prototype focal plane arrays using the improved mercury cadmium telluride epilayers. The array format shall be left to the discretion of the contractor, but an array format of 128 x 128 x 30 micron pixels is the minimum acceptable format. Measure the characteristics of these focal plane arrays. A list of measurements will be provided by NVESD. Obtain imagery using the improved focal plane arrays. NVESD has an imaging test bed that can be used for this imaging demonstration. Optimize the process demonstrated in Phase I to fabricate a prototype LWIR IRFPA. Demonstrate the performance of this array by acquiring 77K imagery.

PHASE III DUAL USE APPLICATIONS: If successful, there would be a high potential for transferring technology developed under this SBIR to the more general electro-optic community, where the dream of monolithic integration of optical sources and detectors on a common Si wafer has yet to be realized because of performance-limiting defects generated during heteroepitaxy. Technologies based on gallium arsenide, indium antimonide, gallium phosphide, and silicon would all benefit from this breakthrough.

KEYWORDS: mercury cadmium telluride, molecular beam epitaxy, long wavelength infrared

A04-120 TITLE: Novel Hyperspectral Sensor Components

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The objective of this SBIR is to develop an innovative design component or sub-system that will improve upon existing hyperspectral sensor technology or be instrumental in the development of new hyperspectral imaging technology. Design proposals may focus on novel methods to improve any of the existing components of current hyperspectral sensors such as: IR FPA enhancement, spectrometer design, hyperspectral optics, or system level performance. Component designs that focus on reducing the physical size or cost of existing technology without decreasing performance are of particular interest. Both LWIR hyperspectral components and combined MWIR to LWIR hyperspectral components will be considered.

DESCRIPTION: From buried land mine detection to basic chemical analysis, the possible applications for hyperspectral imagery are just beginning to be explored. Thus far, several prototype hyperspectral systems have been produced, each with its own strengths and weaknesses. This project will focus on improving some part of the current hyperspectral sensor technology with a focus on ground-to-ground applications. All proposals should assume a minimum 256 x 256 30 mm pitch LWIR or dual MWIR – LWIR FPA operating at a frame rate of not less than 30 Hz with a 14-bit digitization capability. The hyperspectral system should contain a minimum of 100 spectral channels.

PHASE I: Design and demonstrate by analysis a new hyperspectral sensor component. Determine physical and performance specifications of the component such as: spectral range and resolution, field of view, and amount of background radiation emitted to the system. If the component contains optical elements, determine by analysis the amount of distortion (chromatic, keystone, curvilinear, coma, etc.) present in the design. If the design incorporates an IR FPA, include estimates for the NETD, dark current, and spectral crosstalk if applicable. The cost estimates shall include either the projected cost of a full hyperspectral imaging system that incorporates the component, or the projected cost of integrating the component into an existing hyperspectral sensor. Comparison of proposed approach with current hyperspectral technology is highly desirable.

PHASE II: Build, demonstrate, and deliver the hyperspectral sensor component. Prior to delivery, characterize the performance of the system and compare the results to the design calculations performed in Phase I.

PHASE III DUAL USE APPLICATIONS: Potential applications include sensors for land mine detection, chemical analysis, monitoring of terrestrial and atmospheric conditions, and the ability to discriminate between man made and naturally occurring materials.

REFERENCES:
A04-121  

TITLE: Passive Ranging with Motion Detection

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To develop a system for real-time passive ranging with motion detection capability. The system must be based on single or multiple sensors that are based on light, portable, uncooled Infrared (IR) technology but can also incorporate information from other passive sensors such as visible light, acoustic, and seismic sensors. The focus is on passive ranging with motion detection from single or multiple stationary sensors. Solutions based on the movement of the sensors are not of interest. Respondents are encouraged to use creativity suggesting supplementary sensing channels.

DESCRIPTION: Advances in uncooled IR sensors have improved image resolution and quality and made these less expensive, portable devices viable for use by groups of individual soldiers, on unmanned vehicles, or deployed in unattended ground sensors. Also, developments in data fusion have increased the ability to combine multiple data representations (both numerical and symbolic) into coherent structures for decision-makers.

However, as yet, no system has fully utilized these recent advances for passive ranging or motion detection. The idea is to derive range from one or more stationary objects or from motion detected in a sequence of images from a single stationary imaging sensor possibly with information from non-imaging sensors. This can be extended to multiple stationary imaging sensors that may not be collocated. An ultimate goal would be to establish a system to accomplish passive ranging based on a single image from a stationary sensor. Also, using the same sensor data, detect object motion and be able to discriminate it from naturally occurring motion.

The innovation here over previous work would result from the incorporation of passive ranging and motion detection into a single affordable stationary system while eliminating the need for a separate, active ranging device. Passive range and motion detection capabilities would allow for the maximum exploitation of the capabilities of small, uncooled IR sensors to "own the night".

PHASE I: (Respondents are not required to develop hardware for program.)
Will create uncooled IR sensor-based passive ranging and motion detection algorithm(s) from (but not limited to) the above description. Passive ranging will have accuracy to within 1 meter per 1000 meters. Motion detection will be able to discriminate objects moving in the scene from naturally occurring motion such as trees blowing in the wind. Will provide specific and detailed testing plan focused on proving night vision applicability. Will conduct limited tests (artificial environments are permissible at this stage).
PHASE II: Will build and demonstrate functioning and utilizable prototype software system. Will conduct full real image passive ranging and motion detection tests. System will perform successful passive ranging to within 1 meter per 1000 meters and detect object motion, discriminating this from naturally occurring motion.

PHASE III DUAL USE APPLICATIONS: Commercialization of technology would involve all types of night surveillance by dispersed sensors (mobile or mounted, manned or unmanned, or any combination). This would include border patrol, building and property security, and patrolling any large area such as a park or city neighborhood where perimeter fencing is inappropriate. Potentially, the above sensing system could even be used by canine patrols.

REFERENCES:

KEYWORDS: Uncooled Infrared, Passive Ranging, Motion Detection

A04-122 TITLE: Innovative 3-D Imaging for Uncooled and Low Light Level Sensors

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Develop innovative three-dimensional (3D) imaging concepts, utilizing innovative electro-optical and image processing approaches for military head mounted vision system mobility applications. These head mounted display concepts will demonstrate the ability of the advanced technology approach to provide high resolution, wide field of view, three-dimensional imaging in a lightweight, compact package suitable for military applications. The goals of the program are to provide and clearly demonstrate the added utility of 3D imaging performance in a lightweight, compact HMD package for military vision system applications, with particular emphasis on dismounted mobility.

DESCRIPTION: The human visual system provides stereoscopic 3D cues, which provides us with the spatial reference information necessary to successfully traverse rough and cluttered terrain. This same binocular/stereo visual arrangement permits the eye-hand coordination that we casually accept, until such cues are missing. Most military imaging systems have long been deprived of the advantages of 3D imaging due to the monocular configuration of such systems, where cost and weight/cg issues have driven their designs to be monocular. The addition of true three-dimensional cues is expected to enhance the mobility of mounted and dismounted soldiers via improved individual movement techniques (IMT) and better eye/hand coordination, as applied to various military tasks. Additional benefits are anticipated, such as the display of real time range data for potential targets/hazards over the full imaging system field of view. The critical factor of this effort is the cost/benefit of implementing 3D cues into the military system. Innovative hardware and image processing concepts, which neither significantly increase the system cost or weight/cg factors, nor adversely impact human visual factors (such as image latency) for the HMD system are required. This effort will assess the effectiveness of 3D imaging, by providing both a proof of
principle hardware concept demonstrator, and by conducting a laboratory/field analysis to determine the quantitative effectiveness of 3D imaging for military mobility applications.

PHASE I: Demonstrate fundamental materials and design approaches which provide high resolution, wide FOV, low image anomaly HMD implementations of 3D imaging systems. Phase I shall provide proof of concept demonstration hardware to validate the accuracy and practicality of the proposed advanced technology solution and shall incorporate critical design features including, but not limited to the following: compact, low weight display/optic/sensor elements (day video acceptable); horizontal field of view (FOV) > 15 deg; system resolution 640x480 or NTSC/RS-170M; 30 Hz progressive or 60 Hz interlaced video rate; unity system magnification (+10%); head mounted sensors and displays, with bench top processing and system electronics. Phase I hardware shall be self sufficient to permit electro-optic test and measurement by the Government. Phase I hardware may be monochrome, but must demonstrate a design path suitable for full color solution(s) to be pursued in Phase II. A Phase I data deliverable study will address the following military 3D vision system issues: imager noise susceptibility, power consumption, weight/cg, image registration and/or sensor/eye disparity, and Phase II preliminary system design.

PHASE II: Develop materials, components, and image processing techniques for head mounted 3D mobility imaging systems. Fabricate proof of principle demonstration 3D HMD imaging systems that successfully incorporate critical design features, including, but not limited to: compact, low weight display/optic/sensor elements (military sensor bands, VNIR & LWIR required); horizontal field of view (FOV) >40 deg; system resolution 1280 X 1024; 30 Hz progressive or 60 Hz interlaced video rate; unity system magnification (+10%); no visually discernable image anomalies or artifacts; body worn processing and system electronics. Two fully functional demonstrator systems, which demonstrate the ability of the technology to meet the goals, will be delivered to the Government for performance testing and analysis. The display devices shall be delivered with all necessary support electronics to demonstrate both static and motion video imagery. At the conclusion of the Phase II effort, the vendor will provide a quantitative field trial assessment data deliverable of 3D imaging utility for military applications.

PHASE III DUAL USE APPLICATIONS: True 3D, light weight, compact head mounted displays would be beneficial to both the military and commercial sectors. HMD user acceptance is largely dependent on the size, weight, and power consumption of the device, and the fidelity of the image to that of the “real world”. Portable imaging system applications such as augmented maintenance, tele-robotics, fire and rescue, and virtual reality await high performance, 3D HMD devices.

REFERENCES:
3) “Bunker view; limited-range head-motion-parallax visualization for complex data sets” A. State, S. Balu, H. Fuchs Dept. Comp. Sci. UNC at Chapel Hill.

KEYWORDS: 3D, 3-D, Electro-Optic, Stereo, Sensor, Fusion, Miniature, Head Mounted, HMD, Low Power, Lightweight

A04-123 TITLE: High Performance Low-Profile Wave-Guided Head Mounted Display
TECHNOLOGY AREAS: Sensors

OBJECTIVE: The development of an ultra thin wave-guided head-mounted display for use in military applications.

DESCRIPTION: The United States Army intends to utilize head-mounted displays in future systems for use by soldiers, such as Future Force Warrior (FFW). The concept of FFW is to field small, lethal, highly mobile teams with enhanced capabilities stemming from their ability to rapidly exchange information. Head-mounted displays will provide the soldier with information from sensors on or near the soldier, or from a communication link within a larger network. This capability must be delivered without impairing the soldier’s mobility or situational awareness.

In order to optimize mobility, the soldier requires an unobtrusive system. The weight, profile, and center of gravity must be minimal and compatible with the soldier’s headgear, both current and future. In order to maintain situational awareness, the display must have a see-through capability. The soldier of the future will carry a large amount of equipment, and many of the systems will require power. Thus, the HMD needs to be both power and cost efficient as well.

Conventional optics for near-eye systems inherently requires trade-offs between physical size, field of view, and optical performance. An innovative approach is needed to circumvent these trade-offs. Recent advances in technology, such as wave-guided optics, have made the realization of such a system practicable. Wave-guide technology can deliver a system with a thin glass slide shape, while still maintaining the large field of view required by the soldier. This technology, with its ability to provide a low profile, lightweight, high performance solution, brings us closer to the highly sought after “eye-glass” like HMD design.

PHASE I: Demonstrate the feasibility for a wave-guided head-mounted display system by developing the necessary designs and components. The phase I effort should produce a test plate that demonstrates proof of concept. In order to demonstrate feasibility the system designed shall provide at least a 30-degree field of view through a single channel with an eye relief of at least 25 mm, an eye motion box of at least 10 mm, and be able to provide the following capabilities. The technology solution shall maintain a dynamic grayscale of 100:1 over military brightness ranges. The head-mounted display shall have a see-through capability. The system may be either monocular or binocular. The system design shall plan for at a minimum a SVGA display. If necessary, a video card and/or device driver shall be included for the operation of the test plate. The system shall provide a low profile of less than 38.0 mm to the soldiers’ head (including eye relief). Emphasis will be placed on proposals that minimize weight, size, and profile while maintaining good performance across the field of view. Projected technology paths that lead to meeting phase II requirements shall be provided. Specifically, the ability to achieve greater than a 40 degree FOV with a 1280 x 1024 display must be discussed.

PHASE II: Delivery of a hardware demonstrator for an advanced wave-guided head-mounted display system. The system shall provide at least a 40-degree field of view. The display of the system shall have a resolution of 1280 X 1024. The interface between the system and the input to the system for phase II remains to be determined and will be provided by the government prior to awarding the phase II contract. A video card and/or device driver shall be included if necessary for the operation of the system. The system shall deliver brightness to the eye of 100 foot-lamberts and the capability to dim it to 1 foot-lambert or less. Considerations will be given for systems that provide a larger eyebox than the phase I requirement. The system should have an improvement in power efficiency of twice that of current systems.

PHASE III: Development of a ruggedized system suitable for military applications and establishing potential for the head-mounted display technology in dual use applications in commercially available systems.

REFERENCES:
1) Rodney B. Loyd, "Head-mounted Display Systems and the Special Operations Soldier", in Proc. SPIE Vol. 3362, p. 244-251, Helmet- and Head-Mounted Displays III.
2) Mark B. Spitzer, P. D. Aquilino, Robert W. McClelland, Noa M. Rensing, "Toward Eyeglasses-based Electronic Displays", in Proc. SPIE Vol. 3058, p. 178-182, Head-Mounted Displays II.
3) Further information on the current state-of-the-art in military related head mounted display systems can be obtained in the proceedings from SPIE’s "Helmet and Head Mounted Displays" conferences.
A04-124  TITLE: False Alarm Mitigation and Highly Flexible Non-Parametric Decision for Airborne Minefield Detection

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: ASTAMIDS (PM- CLOSE COMBAT SYSTEMS)

OBJECTIVE: Develop state-of-the-art false alarm mitigation filter algorithms and highly flexible non-parametric decision algorithms for improved detection of landmines and minefields using government–provided airborne imaging sensor data.

DESCRIPTION: The Countermine Division of the Night Vision and Electronic Sensors Directorate has a substantial amount of data from a number of existing airborne high-resolution imaging data collection systems with application to the landmine and minefield detection problem. This data was taken over several test sites in the U.S. These data include individual anti-tank (AT) mines, and both surface-laid and buried instances of each. Applicable airborne sensor data primarily comes from passive infrared and active laser sensors operating with a spatial resolution of better than 1.5 inches.

Landmines, as observable from airborne sensors are inherently small objects immersed in a wide variety of natural and man-made “clutter”. The rich variety of such “clutter objects” and clutter-generating phenomena readily produces “false alarms” – false indications of the presence of mines. In order to detect landmines and minefields from the air with enough reliability to permit efficient confirmation by other means, it is necessary to drastically (by an order of magnitude or more) reduce false alarms using all available information extractable from sensor imagery in collaboration with other information sources. Processes for accomplishing this will referred to here as “false alarm mitigation filters”.

High-resolution sensors in the electro-optical (E-O), infrared (IR) and radar imaging domains are now becoming available on a practical basis. These allow landmines to be seen as more than just single-pixel contrast anomalies in sensor images. In qualitative terms such attributes as shape, texture, shadows and specular reflections can now be observed. These offer the prospect for achieving significant levels of false alarm mitigation in individual landmine detections.

The primary purpose of this effort is to develop false alarm mitigation filter(s) and highly flexible non-parametric decision algorithms for improved detection of landmines and minefields using government–provided airborne imaging sensor data from individual bands and from multi-band combinations without reliance upon a priori assumptions of how man-made and natural clutter objects may appear. The goal of the program is to demonstrate that the Unpatterned Surface Scatterable Minefields will be detected with the probability of detection of at least 80% and at least 90% of Surface Patterned Minefields while maintaining an acceptable false alarm rate, typically on the order of 0.5 false alarms per square kilometer for automatic operations. Further multi-sensor data collections, which will include additional sensors, are planned. Additional detailed information regarding the individual sensors is available by email. The proposal should address algorithms for the above sensors.

The contractor will propose to perform the work described for two component algorithm categories specified below:

1. False Alarm Mitigation Algorithms to Enable Improved Landmine and Minefield Detection from Airborne Platforms.
2. Non-Parametric Classification of Objects in Airborne Sensor Imagery for Improved Landmine Detection (The highly flexible decision methods such as non-parametric classification techniques do not require the existence of validated mathematical models. Instead, such techniques form classification rules by compiling observed exemplars of actual mines and clutter instances and partitioning the “space” of observed attributes into mine and no-mine regions with associated confidence estimates).
PHASE I: The contractor will develop and implement processing techniques for reducing the false detections of landmines. At least two distinct false alarm mitigation filters will be developed, one oriented to shape attributes and one oriented to apparent texture attributes of observed anomalies. Also, this phase will develop and implement processing techniques for performing nonparametric classification of anomalies as mines or non-mines. The developed classifier will employ at least four attributes of observed anomalies, preferably including shape, and texture attributes of those anomalies. It will also be directly extendable to a larger number of attributes. The government will supply the contractor with imagery from selected sensor data collections for use in algorithm analysis and development. If necessary, the government will provide the output detections of candidate landmines that were provided by an existing anomaly detection algorithm previously developed for that purpose. A separate data set will be sequestered for use in government-monitored testing of the developed algorithm. In this phase, the algorithm would be implemented in a suitable high-level language such as Matlab.

PHASE II: The task in this Phase is to further develop and refine the processing techniques conceived in Phase I with large quantities of data to maximize and quantify the robustness of the algorithms. To the extent possible the algorithms will be incorporated into the actual data collection systems in order to make near real time assessments. The algorithms will be subjected to the blind tests. The delivered product would be a thoroughly documented software prototype in C/C++ source code with a report or journal paper documenting the rationale and method by which the developed algorithms are intended to operate.

PHASE III DUAL USE APPLICATIONS: This technology has numerous applications in the Army, Navy, the humanitarian de-mining area, and counter terrorism. The system with this technology could efficiently determine clear areas for de-mining effort and land-use surveys.

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

KEYWORDS: Landmine technologies, mine detection, AiTR, non-parametric decision rules, false alarm mitigation
PHASE II: Evaluate and optimize the process from Phase I. Demonstrate the improvements provided by this process using the 3-D noise parameters versus time. Design, build and deliver hardware to demonstrate scene based uniformity correction to correct the non-uniformities of a long wave staring infrared sensor imaging system.

PHASE III DUAL USE APPLICATIONS: The commercialization of this process is expected to provide low cost, high performance uncooled cameras that operate over a wide range of conditions. Potential uses are in a variety of commercial applications including transportation, security/law enforcement, medical imaging, border patrol, homeland security as well as military applications such as night vision devices.

REFERENCES:

KEYWORDS: Electro-optic, detector array, infrared.

A04-126 TITLE: Automatic/Assisted Recognition of Human Intention and Human Group Activity
Intention in IR Images

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

OBJECTIVE: To develop algorithms incorporated into a software package for aided interpretation and recognition of human intentions from their activity using infrared images and image sequences. The software package will integrate state-of-the-art advances in pattern recognition, learning theory, automatic/assisted target recognition, and human-computer interaction. System will enable real-time learning and situation assessment in a cluttered, urban setting.

DESCRIPTION: Over the last 20 years, much research has taken place in the fields of automatic target recognition and classifier systems in general. But the fields remain problematic with significant success often elusive. Even more intractable is the problem of using pattern recognition and machine learning methods to analyze the intentions of humans, singularly and in groups, from their activity in images and image sequences—and to perform real-time threat assessment. Yet the task of determining intentions is most critical given the requirements of modern battlefield situation awareness, e.g., does an observed coordinated set of human behavior signify a group of farmers preparing for a day’s work, or a group of insurgents preparing to attack? The research goal is to optimize the combination of human inferential abilities with computer processing power—often called aided or assisted target recognition. The innovation here over previous work is that as yet, no military system (especially one utilizing infrared sensing technologies) unites contemporary strands of classifier system research into an efficient and effective real-time method for determining the intentions and assessing the threat level of humans and groups of humans in a cluttered environment. Respondents may enhance any classifier technique (support vector machines, deductive systems, etc.) that they prefer.

PHASE I: (Respondents are not required to develop hardware for program.)
Will investigate, enhance, combine, and create assisted human activity interpretation algorithms/methodologies. Will provide specific and detailed testing plan focused on proving applicability. Will conduct limited tests.

PHASE II: Will conduct full interpretation/classifier system tests. Will demonstrate functioning and utilizable prototype software package for surveillance. System package will perform successful human intention analysis and assisted human activity interpretation.

PHASE III DUAL USE APPLICATIONS: Prototype system software will greatly facilitate surveillance (although present algorithms will be developed for IR applications, they should prove easily portable to any visual surveillance system) and protection. Software will be installable in existing corporate or government surveillance facilities and enhance analysis of human activities being monitored. This would include border patrol, building and property security, and patrolling any large area such as a park or urban neighborhood. Potential applications also exist where a human-in-the-loop is supervising multiple sensors, such as in a security center or operations room. Specific examples follow: 1) monitoring high crime areas for gang or drug related activity; 2) theft prevention in
retail operations; 3) guarding ranches or agricultural areas; 3) preventing prisoner on prisoner abuse in prisons. Applications exist wherever large groups of people or areas must be monitored in real time—where cues to human intention could aid observers' quick analysis of large amount of data.

REFERENCES:

KEYWORDS: Infrared, Target Recognition, Surveillance, Classifier

A04-127 TITLE: Modeling and Simulation of Spectral and Spatial Efficiency, Communications Bandwidth and Range Optimization and Security Performance in a Directional Networked Communications Environment

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Warfighter Information Network - Tactical (WIN-T)

OBJECTIVE: To develop a modeling and simulation capability to assess the trade-offs between design considerations of directional communications using focused antenna beams and its effect on effective data rates, communications range, Anti-Jam (AJ) and Low Probability of Intercept/Low Probability of Detection (LPI/LPD) performance.

DESCRIPTION: Directional networked communications can be achieved with narrowly pointed antenna beams using specialized antennas and/or signal processing techniques. Directional networked communications can be used to increase capacity in a limited frequency spectrum environment by improving on spatial reuse, increased communications distances as well as improved Radio Frequency (RF) security performance such as AJ and LPI/LPD.

The United States Army currently has ongoing efforts to develop high capacity communications/data links using frequency ranges of above 2 GHz for communications, sensor data dissemination, and position/location reporting, etc. The MARCON-I STO is a US Army Communications-Electronics Research Development and Engineering Center (CERDEC) research and development project that focuses on the development of a high capacity, LPI/LPD waveform. The Program Manager (PM) Future Combat System (FCS) Networked Data Link (NDL) and the PM
Warfighter Information Network-Tactical (WIN-T) high capacity waveform are potentially directional network waveforms that have data rates up to 10 to 100 Mbps.

There is a need to develop modeling and simulation tools to assess the benefits and limitations of directional networked communications using directional antennas in a tactical, potentially RF hostile environment with limited frequency spectrum.

The modeling and simulation capability is essential in the assessment of the performance of a directional network waveform in a tactical battlefield environment. This is a highly useful tool in actual directional waveform development as well as communications network planning in the field. The modeling and simulation capability will allow systems developers to determine achievable capability metrics such as data rate, range of communications, level of LPI/LPD against given known parameters such as transmit power, beamwidth, number and location and positions of friendly and enemy nodes, channel access schemes as well as network topology and routing protocols. Modeling results are critical in the design and analysis of RF directional communications systems for the tactical battlefield.

PHASE I: Research and develop methods and algorithms to model physical layer, channel access layer and network layer attributes of a directional network waveform in various RF conditions and physical environments. Determine appropriate modeling and simulation tool and platform to use. The modeling effort should be applicable in the frequency range of above 2 GHz. The model should include parameter and metrics such as data rates, communications range, LPI/LPD, number and location of nodes, beamwidth, etc.

PHASE II: Develop software that implements modeling algorithms and methods for the directional network waveform developed in Phase I. Combine commercial/military off the shelf software with developer software to realize a complete modeling and simulation system.

PHASE III DUAL USE APPLICATIONS: The modeling and simulation tools developed can be used in the design and integration of directional communications systems for the military services. PM FCS, PM WIN-T can use the modeling and simulation tool for high capacity waveform design and integration onto Joint Tactical Radio System (JTRS) product platforms. The developed capability can also be utilized by other CERDEC STOs such as Communications Planner with Realism (CPR).

Commercial applications, such as cellular LANs and some cellular WANs, which use independent radio channels made possible by deploying directional antennas to gain better frequency reuse, can certainly benefit from using this modeling and simulation capability to better plan and utilize their cellular networks.

REFERENCES:

KEYWORDS: spatial, frequency, spectrum, directional, network, modeling, anti-jam, LPI, LPD, RF
ACQUISITION PROGRAM: PM WIN-T

OBJECTIVE: To increase the efficiency of Monolithic Microwave Integrated Circuit (MMIC) Power Amplifiers from the present 15-20% to 40-60% by utilizing integral ferroelectric capacitors for input, output and frequency/bandwidth tuning. The end product of Phase II will be High Efficiency MMIC amplifiers.

DESCRIPTION: The current problem is that MMIC amplifiers have only 15-20% efficiency when operated in the class AB mode required for phased array antennas. This causes excessive power consumption and a resultant heat dissipation problem. This requires large air-air or liquid-air heat exchangers. The challenge is to increase the efficiency of these amplifiers to reduce the power consumption and cooling requirements.

These power amplifiers will be utilized in Satellite Communication (SATCOM) antennas for the Warfighter Information Network-Tactical (WIN-T) and Multiband Integrated Satellite Terminal (MIST) programs. These on-the-move SATCOM Antennas are for Global Broadcast Service (GBS), Wideband Gapfiller Satellite (WGS) and Advanced Extremely High Frequency (AEHF). Currently, these antennas suffer from excessive power consumption and a resultant heat removal problem. The current heat exchangers required for phased arrays are 7 inches high, turning a low profile antenna (< 5 inches high) into a high profile antenna (> 12 inches high). Dish antenna systems suffer a more modest power dissipation problem.

PHASE I: Phase I will result in the design of new MMIC amplifiers with integrated tuning networks using ferroelectric capacitors. This will result in increased efficiency by dynamically matching the input and output of the MMIC amplifier as well as programming its center frequency and bandwidth. Designs will include 30 to 31 GHz amplifiers for Wideband Gapfiller and 43.5 to 45.5 GHz for AEHF.

PHASE II: Phase II will start with the Phase I design and result in fabrication of initial high efficiency MMIC amplifiers. The MMIC amplifiers will be tested in a breadboard, the designs modified as required and additional amplifiers fabricated and tested. It is anticipated that three or four iterations will be necessary. The final MMIC amplifier prototypes will be demonstrated by the contractor to highlight the increased efficiency and reduced cooling requirements achieved.

PHASE III DUAL USE APPLICATIONS: PM WIN-T MIST program dish antennas and multibeam phased arrays for GBS, Wideband Gapfiller and Advanced EHF. Commercial phased arrays for high data rate communications.

REFERENCES:
1) CECOM Space & Terrestrial Communications Directorate Broad Agency Announcement, DAAB07-03-R-P650, Topic S0401.
2) Comparetto, Gary and Bill Hall, "Multi-Band Integrated Satellite Terminal (MIST) - A Key to Future SOTM for the Army."
   http://www.mitre.org/work/tech_papers/tech_papers_01/comparetto_multiband/comparetto_multiband.pdf

KEYWORDS: MMIC Amplifiers, Ferroelectric Capacitors, Phased arrays, High Efficiency

A04-129 TITLE: Networked Micro-Radios for Micro-UAVs

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: US Special Operations Command

OBJECTIVE: Develop a technology capable of providing micro-digital wireless radio networking of real time streaming video data across micro UAVs.

DESCRIPTION: Micro-UAV’s will play a key part in the Future Combat Systems (FCS) and the Objective Force visions by providing real-time look-ahead situational awareness via a suite of advanced sensors. To enable this
capability, a networked unified communications ensemble is required for relaying the data generated by the UAV sensor systems and for the remote control of the platform. This self-contained, wireless, mobile, ad-hoc, power efficient communication system must be capable of monitoring each UAV’s array of sensors, command and control functions, and possibly weapons. The communications system should incorporate a radio frequency (RF) waveform that provides for low probability of intercept (LPI), low probability of detection (LPD), and high anti-jam (AJ) characteristics. The (RF) waveform and radio hardware shall be capable of providing both robust and reliable communications networking in complex environments where difficulties occur from high path losses and multi-path fading. The radio shall also be immune to any effects from the movement of the higher speed aerial vehicles (Doppler effect, frequency shift, etc.). System attributes must include: data integrity and data privacy via the use of a data encryption and key management scheme suitable for unattended and unmanned vehicles, ‘isolation’ so that the locations of the unattended vehicles cannot be ascertained, and networking controls so that the unattended vehicles and payloads are immune to unauthorized use. As available bandwidth of communication channels vary, the communications system should incorporate a dynamic and variable digitized video quality/compression compensation scheme. The communications system should incorporate dynamic data packets, packet headers, and packet trailers (header compression). Use of these will provide for a decrease in overhead as repeated information is transmitted. The communications systems should be responsible for changing packet structures, headers, and trailers automatically and without user intervention. It is envisioned that an operator will have control of at least three UAV’s simultaneously. All command and control functions, sensor data, and video links should be accessible to the operator at all times. While it may not be necessary for an operator to view all video links simultaneously in high quality, the network should be able to do so. There is also a growing market for sensor networking applications for remote monitoring of sites such as utility pipelines and factories that could reduce the unit costs of the communications devices. However, military security requirements such as low probability of detection, privacy, authentication and information assurance will be maintained. For Dual Use applications, these features may be turned off when not needed. The features also could be used for Homeland Security Counter-Terrorism applications when security is needed but not to the level required by the tactical military.

PHASE I: Identify, through analysis, simulation, and modeling a preliminary system architecture, hardware technology, and design plan for candidate communications concepts leading to a practical implementation of a self-contained micro-radio network for UAVs in accordance with the topic description and objective.

PHASE II: Implement and demonstrate the candidate concepts and technologies identified in Phase I. A prototype system will be built for proof-of-concept lab and field evaluations of fully functional micro-radios based on the concepts and metrics developed in Phase I.

PHASE III DUAL USE APPLICATIONS: The system evaluation will include demonstration of the ability to satisfy the payload requirements of the US Army’s Class II UAVs and the ability to establish and maintain networked communications links (point-to-point, not multi-hop) at 50 kilometers line-of-sight range. Transition planning to the FCS will occur during this phase. Transition of this SBIR into Phase III will consist of migration into the Army FCS program, PM SOCOM, and eventual commercial initiatives for homeland security and remote aerial surveillance including deployment by the Forest Service and Search and Rescue Teams. The transition potential to military and commercial usage is considered very high.

REFERENCES:


4) University of CA. at Berkeley website, http://robotics.eecs.berkeley.edu/~pister/SmartDust

KEYWORDS: UAV Communications Network spread spectrum protocol multi hop
TITLE: Laser Agile Multibeam Payload

TECHNOLOGY AREAS: Electronics

OBJECTIVE: This program will address multimission functionality of a laser system, which combines communication, tracking and countermeasures in one complete C4ISR optical system. This effort would focus on non-mechanical, multi-aperture, multi-beam systems. Laser systems for Army platforms have cross-functional hardware. It would be advantageous combine system functions for reduced size, weight, power and cost. Multiple independently-steered beams are necessary to increase link availability of a node to form a robust network.

DESCRIPTION: Optical countermeasure systems, laser target tracking, and free space optical communication have been developed as separate optical systems. Because of the size, weight and power (SwaP) constraints of current military payloads, it makes sense to combine functionality of these systems. This vision may includes a common pointing and tracking systems, common laser optics, transmit and receive subsystems, and adaptive optics. By using these common subsystem elements, you can achieve a dramatically reduced size, weight and power (swap) and maintain individual technical functionality. DARPA had begun to address this need in its Steered Agile Beams program, which started in 2000 and has recently ended. This program has shown significant promise for the development of multi-functional optical systems; however, the maturity of the program is still in the early laboratory development stages (technology readiness level 3/4). There has been a good body of work in non-mechanical, vibration resistant pointing and tracking system. Also, there has been promising technology to support optical multi-beam apertures. It is intended that this effort leverage on current developments to mature this technology to a TRL of 6 after the Phase II.

PHASE I: The concept design of the multi-beam, multi-aperture system can have many potential configurations. The challenge is to investigate which design makes sense for combining these distinct, but related functions. The emphasis should be placed on developing a system that can show individual beam steering, multiple beam transmission, either through a common AND/OR multiple aperture, and integration of new or legacy communication, targeting and countermeasure system. The system design should be modular in which it can incorporate legacy or new systems.

PHASE II: This phase will further develop the concept to key technology milestones. The thrust of this effort should be placed on subsystems development, interim technology demonstration and integration. A final working prototype shall be delivered and demonstrated. Military robustness and functionality should be accounted. Phase II TRL goal is 5, but can exceed this maturity level, if possible, towards TRL 6.

PHASE III: Commercial applications: Potential commercial application include high bandwidth video transmission, multiple building-to-building LAN backbones, long distance communication links, spectroscopy, sensor imaging, collision sensing, industrial manufacturing, chemical, environmental, and food sensing, optical routing, wavelength-division multiplexing (WDM) optical networks, bandwidth-on-demand applications, metropolitan area networks, "last mile" network connectivity, remote sensing, infrared Personal Data Assistants (PDAs), and remote computing. Military Applications: Supports Transformational Communication Architecture (TCA), multiple antenna remoting, distributed command and control, local area networks, and high bandwidth, fixed plant applications, on-the-move multimode communication, integrated C4ISR optical systems.

REFERENCES:
Defense Advanced Research Projects Agency (DARPA Programs: www.darpa.mil

Steered Agile Beams (STAB) Program

Terahertz Operation Reachback (THOR)
Optical & RF Combined Link Experiment (ORCLE)

Future Combat Systems (FCS) Communications


KEYWORDS: high speed networks, high capacity communication, wavelength division multiplexing, optical networks, laser communication, optical MEMs, optical beams, multimission payloads, optical beamsteering

A04-131 TITLE: RF (Radio Frequency) Communications for Unattended Ground Sensor and Munition Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PM WIN-T, PEOC3S

OBJECTIVE: To understand and improve the UHF (225 to 500 MHz) RF communications for unattended ground sensor and munition systems. Research is needed to develop improved antenna systems and RF propagation modeling between low-altitude, very-near-ground, antennas. Improved antennas are needed to increase the link budget. An improved RF propagation model is required that can accurately analyze the low-altitude terrain, for link analysis and communication network deployment.
DESCRIPTION: Research in novel concepts, design capabilities and solutions for small UHF antennas operating in the 225-500 MHz frequency band. The currently available UHF antennas do not have the combination of communication performance, small size, ruggedness/reliability and low cost. The required UHF antennas will support radios embedded in Unattended Ground Sensors (UGS), which in turn will provide communication links to and from other sensors and intelligent munitions. The sensors and munitions are small and light enough to be hand emplaced in selected situations but objectively they will be deployed by projectile delivery systems permitting rapid delivery over relatively large areas. It is envisioned that some of the sensors and munitions will be deployed typically hundreds of meters apart over diverse terrain features with low proximity to the ground (approx. 0.2m). Other sensors will be elevated above ground (approx. 1.0m) to facilitate image capture and longer range communications. The required antennas should provide omni-directional coverage, and objectively be able to support the various deliverable means described above. This includes designs of circular polarized antenna that may improve connectivity with banking airborne communication platforms.

The communication architecture requires communication between sensors and/or munitions that have antennas approximately 0.2m high. The communication between the sensors node is approximately 200 to 400 meter and the sensor network link-back communication is approximately 7 to 10 km. Due to the antenna located close to ground, in a low-altitude, the propagation may suffer substantial back scattering and scattering from the irregular terrain as seen by the low-altitude antennas. Since the antennas are omni directional, there may be substantial scattering due to out of line-of-sight lateral reflection, and foliage loss and other rough surface scattering should also be considered. These propagation conditions indicate a critical need to develop a low-altitude propagation prediction model. The standard TIREM (Terrain Integrated Rough Earth Model) model cannot be used for low-altitude antenna path-loss prediction, as this model is applicable for directive, high-altitude and high frequency propagation condition.

The proposed propagation model solution would need to include ground wave effects. A possible solution may use a hybrid technique with FDTD and Moment Method (NEC-BSC). For this purpose NEC-BSC code will be used to develop a propagation model that can accurately predict scattering from irregular terrain. The FDTD model will be used to model the antennas and predict scattering in the near-field zone. This hybrid model will use 3-D terrain data considering the effect of multiple scattering.

PHASE I: Investigate innovative antenna designs in the 225 to 500 MHz frequency range, and RF propagation modeling techniques and methods for communication between low-altitude antennas.

PHASE II: Finalize antenna design, fabricate and test antenna prototypes. Develop software that implements modeling techniques and methods develop in Phase I. Combine commercial/military-off-the-shelf software with developer software to realize a complete modeling system. This includes modeling, meshing, solving for the electromagnetics characteristics, and viewing the outputs. The propagation modeling tool should be able to run, operate independently and interface, interoperate, with COTS communication network planning modeling and simulation tools. Model the RF propagation of an Army unmanned sensor/munition communication network with both legacy and the newly developed antennas. Validate model with field measurement data. Government field measurement data should be used when available and government provided. Both the antenna prototypes and the propagation modeling tool should be demonstrated in realistic scenarios to potential government and industrial users.

PHASE III DUAL USE APPLICATIONS: Advanced antenna design can be used to improve communication on multitude of both military and commercial platforms. The modeling and simulation tools developed can be used in the design and integration of communication systems for both military and commercial ground, air and water vehicles. PM Warfighter information Network-Tactical (WIN-T) can use the modeling and simulation tools for the system integration of the Joint Tactical Radio System (JTRS) antennas onto various platforms. The FCS Program may likewise use the developed tools for communication system integration. Commercially, companies would utilize these modeling and simulation tools to optimize the deployment of communication network. Installation and testing of the new antenna on Army unmanned sensor/munition communication network, and the use of the low-altitude propagation modeling tool to plan, configure, network deployment to demonstrate improve communication network performance comparing to the legacy system.
REFERENCES:
1) http://spie.org/Conferences/programs/01/or/conf/4393.html

KEYWORDS: Antenna, propagation, modeling, radio, UHF, communication

A04-132 TITLE: Models for Accurate & Scalable Analysis of Future Communication Systems

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, Warfighter Information Network - Tactical (WIN-T)

OBJECTIVE: The objective is to investigate ways to provide hardware-in-the-loop models for wireless and wired networks, where part of the communication network is realized as a physical network and the remainder as a simulation or analytical model. Such a system will allow for the performance characterization of modeled communication devices, protocols, radios etc. across both physical and virtual domains as well as homo- and heterogeneous HW/SW environments.

DESCRIPTION: Build models that will provide hardware-in-the-loop models for wireless and wired networks, where part of the communication network is realized as a physical network consisting of Commercial Off the Shelf (COTS) and/or military radios and the remainder simulated or analytical models. This system will allow for the performance characterization of modeled communications devices protocols, ratios etc. Scalability to ten's of thousands of nodes may be realized with this system.

PHASE I: This effort will entail a preliminary plan to study the unique problems associated with the feasibility of hardware-in-the-loop models for wireless and wired networks in the lab, where part of the communication network is realized as a physical network and the remainder as a simulation or analytical model. Proof-of-concept simulations and demonstrations of the feasibility of hardware-in-the-loop are highly encouraged, as well as innovative ideas in radio/other technologies. Any prototype systems will have to make use of current commercial M&S software’s current ability to characterize network performance over diverse network configurations and mobility scenarios using statistical traffic generation as well application model-driven traffic generation (i.e., VoIP, ftp, http, etc). This kind of traffic generation will be incorporated with realistic terrain modeling to assess the performance, collect statistics of (modeled) RF hardware and protocols in a realistic noise/RF propagation environment. Candidate systems with a high probability of successful implementation will be developed for Phase II.

PHASE II: This effort shall implement the design goals explored in Phase I. The overall goal is to deliver a fully functional prototype system exhibiting the desired communications hardware-in-the-loop capability. Design, then implement appropriate interfaces and synchronization mechanisms to support current/future communications networks with many thousands of nodes. Phase II must culminate in a physical demo of the capabilities enumerated in Phase I in the virtual lab.

PHASE III DUAL USE APPLICATIONS: Use the virtual lab to scale up the performance studies of SLICE, FCS, WIN-T, JTRS or other future radio technology programs. Commercial applications: For First Responders, Portable telecommunications, and Cellular telephony. Military Applications: Network management, Sensor Networks, Current and Future Communication systems

REFERENCES:
2) Presentation for Advanced Networking http://www.hcs.ufl.edu/prj/opngroup/RockwellMtg26Aug03.ppt
KEYWORDS: communications, networking, hardware-in-the-loop

A04-133 TITLE: Superconductor Technology for SATCOM Applications

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PM DCATS

OBJECTIVE: Study the design architectures needed to produce low thermal noise, highly linear and high speed digital superconducting micro-electronics circuits. Provide conceptual designs of ADCs (analog to digital converters) and digital channelizers operating in the MILSATCOM RF frequency bands from L-Band to Ka-Band that can replace traditional analog RF circuits with their digital equivalents. Verify the potential that these digital RF components can replace LNAs and frequency down converters over the MILSATCOM RF operating bands.

DESCRIPTION: Superconductor RF Technology with its extreme high speeds and high fidelity provides the promise of vastly improved performance in satellite communications RF applications. High speed low noise amplifiers, analog to digital converters and subsequent digital signal processing provide the opportunity to replace non-linear analog communications products with their high fidelity digital equivalents. The resulting products are expected to exhibit lower thermal noise, increased sensitivities and higher spurious free dynamic range than with conventional techniques. The resulting digital RF receivers and transceivers can replace analog low noise amplifiers and frequency converters with a single programmable digital product.

PHASE I: The objective of Phase I would be to study and develop conceptual designs, based on superconductor technology, for high frequency low noise amplifiers, band pass analog to digital converters and digital channelizers capable of operating over the MILSATCOM frequency band, to include L-Band, X-Band, Ka-Band and EHF Band. The resulting circuits would have the capability of low noise amplification, selection of specific frequency bands of interest, performing frequency translation and band filtering to derive a baseband signal for further processing. At L-Band, the resulting circuits can be used to replace non-linear, fixed analog hardware with precise, flexible digital conversion products that is Software Communications Architecture (SCA) compliant. At X-Band, Ka-Band and EHF Band the resulting circuits, in addition to replacing non-linear analog hardware, but also provide significant G/T improvements. During Phase I, several alternative circuit architectures will be investigated and a plan for progressive development established.

PHASE II: The objective of Phase II would be to demonstrate an ultra low noise, high fidelity X-Band all digital RF receiver using superconducting electronics for the next generation MILSATCOM applications. Specific technical objectives of the Phase II project would include: Develop superconducting High Frequency (X-Band) low noise amplifiers and analog to digital converter with very high signal-to-noise ratio (SNR) and spur-free dynamic range (SFDR) that can meet the requirements of future software radios for both military and commercial satellite communications. Verify the ultra low noise RF front end characteristics that confirms significant improvements in the figure of merit (G/T) of SATCOM terminals. Demonstrate High fidelity, bandpass, frequency translation from X-band to baseband directly in the digital domain using a single stage digital frequency down converter.

PHASE III DUAL USE APPLICATIONS: The superconductor Digital RF technology once developed should be capable of supporting a wide range of communication applications, bringing the full power of digital processing to all communication functions. In addition to communication systems, a broad range of DoD and commercial operations should benefit from the digital signal processing and high-bandwidth characteristics of the new receiver. The success of this work should provide the basis for a whole new generation of RF communications hardware, with particular application to software-defined radio (SDR). The front-end architecture of the military wireless, MILSATCOM and commercial SATCOM and wireless systems are all similar, both involving direct conversion between analog and digital domains at RF frequencies. These digital RF subsystems can provide wideband and narrow-band OBJECTIVE-level performance for WIN-T, FCS, TCA and JTRS communications systems as well as SIGINT. Similarly, the same technology, once developed for the commercial SATCOM frequency bands, can be directly utilized in the commercial SATCOM market place.
PHASE I: Develop a feed design that will simultaneously Tx/Rx a minimum of two (Ku and Milstar/AEHF) frequencies for proof of concept demonstration.

PHASE II: Further develop and demonstrate a feed design that will simultaneously Tx/Rx a minimum of three (X, Ka, Milstar/AEHF, WGS) frequencies and demonstrate an integrated prototype system in a realistic environment.

PHASE III DUAL USE APPLICATIONS: This feed could be used in a broad range of military and civilian applications where there is a need for stationary, on-the-move (OTM) and on-the-pause (OTP) multi-band communications – for example, peacekeeping/rescue/emergency response/disaster relief operations, mobile news coverage, and situations requiring high volume voice and data transmissions.

REFERENCES:
2) Comparetto, Gary and Bill Hall, "Multi-Band Integrated Satellite Terminal (MIST) - A Key to Future SOTM for the Army."
   http://www.mitre.org/work/tech_papers/tech_papers_01/comparetto_multiband/comparetto_multiband.pdf

KEYWORDS: satellite communications, SATCOM, multiband, multi-band, feed, COTM
TITLE: Subterranean Communications for First Responders and the Military

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PM Warrior Information Network-Tactical (WIN-T)

OBJECTIVE: The primary objective is to design and demonstrate a prototype wireless system with the desired communications capabilities in extreme subterranean environments. A complete prototype system shall be demonstrated with a network of at least ten nodes.

DESCRIPTION: This topic will investigate wireless communications in extreme urban and underground environments. Novel technologies to permit voice/data/video communications within and to the outside of buildings (collapsed or erect), subways, tunnels, mineshafts, deep bunkers, caves, etc., will be considered. Models of propagation and of multi-path in and around buildings, as well as the channel characteristics in these extreme environments may be developed/used.

PHASE I: This effort will entail a preliminary plan to study the unique problems associated with wireless communications in the extreme subterranean environments. This phase may include system architecture definitions and design plans, modeling and simulation, laboratory demonstrations, and proof-of-concept implementations. Simulations and demonstrations are highly encouraged, as well as innovative ideas for inexpensive, disposable communications incorporating state-of-art wireless techniques and/or possible use of other than RF technologies. Candidate systems with a high probability of successful implementation will be developed for Phase II.

PHASE II: This effort shall implement the design goals explored in Phase I. The overall goal is to deliver a fully functional prototype system exhibiting the desired communications capabilities in the extreme subterranean environments. Emphasis will be placed on size (<8 cu. in.), weight (<8 oz.) and power (battery life > 48 hrs.), communication range (nominal 100 ft. on single hop), operational environments, and interoperability with military and civilian authorities. A final prototype networking system shall be delivered and demonstrated. The prototype network shall consist of ten (10) or more nodes and shall be demonstrated in a subterranean environment, and shall be self-organizing, self-healing, and energy efficient.


REFERENCES:

KEYWORDS: subterranean communications, urban communications, expendable relays, propagation, radio technology
sensitive TWNA data will be released to the contractor, all contractor personnel proposed to work on this SBIR effort must be U.S. Citizens and possess security clearance up to the secret level. Also, the proposed contractor facility must be cleared up to the secret level. The Intrusion Tolerance and Survivability solutions formulated would be extremely useful to both the commercial and military worlds. Note that it is anticipated that the Intrusion Tolerance and Survivability solutions formulated would also be extremely beneficial in the Homeland Defense application by enhancing the Intrusion Tolerance and Survivability of critical mobile computer network infrastructures.

DESCRIPTION: In both the commercial world and military world Computer Network Intrusion Tolerance and Survivability for Mobile Networks is being recognized as a major emerging problem. It is vital to protect and enhance computers and computer networks against hacker and foreign power threats. There has been some research into Computer Network Intrusion Tolerance and Survivability (especially for wired networks), but there is a dearth of commercial solutions for Computer Network Intrusion Tolerance and Survivability (especially for wireless, mobile networks). This research will investigate new and innovative approaches for Computer Network Intrusion Tolerance and Survivability for mobile, wireless networks.

PHASE I: Perform a study of TWNA Intrusion Tolerance/Survivability techniques. Specific areas to examine under TWNA would be the Policy Management Server and the Bandwidth Broker functions. Required data concerning efforts to date would be provided to the successful bidder. The contractor would then perform a study to enhance the TWNA Intrusion Tolerance/Survivability features. At the end of Phase I, a set of alternative enhancements would then be presented to the government. The contractor and the government would make a joint decision on the most promising techniques to pursue in Phase II.

PHASE II: The most promising techniques emerging from the Phase I effort would be further developed and modeled. A performance description or specification would be developed. A prototype software working model will be delivered.

PHASE III DUAL USE APPLICATIONS: Military use would include security solutions for soldiers who utilize mobile, tactical, wireless networks. These networks are becoming more prevalent in the military. Commercial uses would include personnel who are assigned to use mobile wireless networks in such diverse industries as banking, electric power utilities, water utilities, telephone systems, police and emergency civilian personnel, etc. Note that it is anticipated that the wireless Computer Network Intrusion Tolerance and Survivability solutions formulated would also be extremely beneficial in the Homeland Defense application by protecting critical wireless computer network infrastructures.

REFERENCES:
1) An Intrusion Tolerance Approach for Protecting Networks. Cheung, citeseer.nj.nec.com/cheung99intrusion.html
2) Intrusion Tolerance in Distributed Computing Systems Jean-Charles, Fabre citeseer.nj.nec.com/deswarte91intrusion.html
3) Advanced Systems and Network Security www.cc.gatech.edu/classes/AY2003/cs8893k_spring/

KEYWORDS: intrusion tolerance, network survivability, mobile networks, tactical networks

TITLE: Network Scalability and Performance Analysis

Topic Canceled

TITLE: Modeling of Composite Materials for a Survivable Ballistic Antenna Radome

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: The objective is to investigate ways to employ modeling and simulation for the design of an antenna radome that will have low RF loss. They will be used on On-The-Move (OTM) Future Combat Systems (FCS) platforms and must withstand ballistic impacts from exploding shells and small arms fire. Modeling goals are to
show a low cost approach with an operational frequency range of 225-2500MHz, with an Effective Isotropic Radiated Power (EIRP) from the antennas in the 50-100 watt range. The radome will be modeled for use with On-The-Move (OTM) FCS platforms.

DESCRIPTION: The project will use state-of-the-art electromagnetic simulations to characterize materials and geometries of the radome in order to arrive at an effective design solution. Development of advanced specific electromagnetic modelling techniques minimizes the possibility of "trial and error" testing through the simulation of the radome electromagnetic properties. High confidence in an effective design solution, before prototyping and testing, will be possible by pursuing this SBIR.

PHASE I: This effort will entail a preliminary plan to study the unique problems associated with the feasibility of implementing an appropriate modeling and simulation environment to model composite materials. The composite materials will be applied to model a low RF loss, impact resistant radome. Development of algorithms, mathematical, models to support the composite materials used to model an objective survivable radome will be developed and demonstrated during this phase. Candidate models and simulation environments with a high probability of successful implementation will be developed for Phase II.

PHASE II: During this phase, the modeling environment selected must be able to show a migration path from design and modeling to fabrication. Advanced visual modeling to include 3 Dimensional (3D) representations of radiation patterns including absorption and reflection. Modeling of ballistic impacts on the radome from a variety of exploding shells and small arms munitions will be demonstrated. The models implemented during this phase will be verified and validated to be accurate representations of realistic materials and ballistic impacts.

PHASE III DUAL USE APPLICATIONS: Modeling environment will be enhanced to directly feed the construction of a radome prototype. This will be achieved using industry standards to move from model to the actual physical construction and test. Commercial applications: Portable telecommunications, Satellite and Cellular telephony. Military Applications: Current and Future Communications Systems.

REFERENCES:
Radomes/Materials:
2) http://www.radome.net/
5) http://www.grc.nasa.gov/WWW/RT2001/5000/5920choi.html
6) Electromagnetic Modelling:
7) http://www.emclab.umr.edu/numer.html

KEYWORDS: communications, antennas, munitions, composite materials, radomes

A04-139 TITLE: Biobatteries

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Land Warrior

OBJECTIVE: The objective is to develop and provide biological batteries using whole microbial cells (bacteria, yeast) in a microfabricated biofuel cell to power unmanned sensors and low power draw equipments such as sight, illumination and biological sensor devices.

DESCRIPTION: A soldier deployed on the field on a 72-hour mission carries a load of 140 lbs, of which batteries are a significant component. In addition to weight, there is also a monetary cost. A 12 man SOF team on a 30 day mission, for example, needs access to ~4000 batteries at a cost > $300k. Many of these batteries power devices such as sights, illuminators and individualized sensors (outside and implantable) suite, which draws milliwatts.
Conventional batteries (and fuel cells) are inadequate in fully meeting this challenge (size/weight, high temperature, acidity, alkalinity, non-renewable, non-implantability, toxicity, waste issue, expendable procurement logistics etc.). Biobatteries (biofuel cells) is the answer; they are devices that convert biochemical energy directly into electrical energy. They are distinguished from conventional fuel cells by the use of biomass (such as carbohydrates, sugar, etc) as a fuel instead of hydrogen. Biobatteries can be operated at near neutral pH and at ambient temperature. The fuel is readily available, from humans, animals and vegetation sources. They are renewable and are easily scaleable to support program requirements as they evolve.

Many studies have been focused on enzyme based fuel cells that uses biological enzymes, such as glucose oxidase, to convert glucose into gluconolactone at the anode while the cathode uses the redox enzyme laccase to covert dioxygen to water. This system is capable of delivering 64mW/cm² at 0.4V, enough to power a biosensor. The disadvantage of this system is that the enzymes are very sensitive to pH and temperature. To achieve a more versatile biobattery, whole microbial cells need to be studied and developed to replace the enzyme-based biobattery. A potential is the use of Rhodoferax ferrireducens, a microorganism that converts simple and complex sugars into electrical energy.

PHASE I: Fabricate proof-of-concept batteries capable of delivering several milliwatt-hr/cc.

PHASE II: Fabricate batteries for test and evaluation focusing on performance. Target performance: 300 milliwatts-hr/cc.

PHASE III DUAL USE APPLICATIONS: Fabricate batteries for application specific test and evaluation for sensors and low draw devices.

REFERENCES:

KEYWORDS: Soldier Power, Energy, Biotechnology, Biosensors, Sensors, Fuel Cells
nanotube design should address the specific smoke performance goals of high extinction coefficient and high dissemination efficiency. This can probably be achieved with a length distribution peaking at several microns, increased conductivity above that intrinsic to carbon nanotubes and high permissible levels of soot impurities. Smoke performance associated with wall structure and purity must be determined as well as that associated with increasing carbon nanotube conductivity.

PHASE I: Produce 10 milligram quantities of modified carbon nanotubes and disperse into a liquid media for spectroscopic cell analysis of the extinction coefficient. Consideration should be given to the cost goal and feasibility to manufacture in commercial quantities.

PHASE II: Produce 100 gram quantities of carbon nanotubes sufficient for chamber evaluation and develop a method for aerosolization of the material into the chamber. Show that it is potentially feasible to commercially produce the material economically (< $100/kilogram) and in 10 ton quantities within several years.

PHASE III DUAL USE APPLICATIONS: This material has potential commercial use in hostage recovery situations and break-in protection/security systems, paint pigments, makeup, Electromagnetic Interference (EMI) shielding, batteries. The military application is in IR threat sensor countermeasures.

REFERENCES:

KEYWORDS: smoke, obscurant, screening material, infrared, aerosols, nanoparticles

A04-141 TITLE: Ultra-Compact Carbon Dioxide Laser For Chemical Sensor

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

ACQUISITION PROGRAM: Artemis

OBJECTIVE: We are seeking novel approaches to demonstrate feasibility of a very compact carbon dioxide (CO2) laser for standoff chemical detection to support ranges of at least 5 km in a small package such as an Unmanned Aerial Vehicle (UAV) or a Manportable sensor.

DESCRIPTION: Medium to large size CO2 laser-based active standoff systems have been developed by the U.S. Army ECBC to address the chemical aerosol and vapor threats. The FAL (Frequency Agile Laser) REF 1) system is the current state-of-the-art. It was initially developed in 1990 and has been subsequently used successfully in numerous field trials. However, very little development of the FAL laser has been undertaken in the intervening years, especially with respect to reducing critical component size and weight. The present FAL weighs approximately 100 lbs and occupies a volume of roughly 3 cu ft which would be far too large for deployment on small platforms. Further work is needed to reduce size and weight and to demonstrate other aspects of the laser important for integration with a sensor.

In order for a CO2 laser to be useful for a standoff chemical sensor, it is necessary to provide acceptable output energy also on weak lines such as 9P44. Furthermore, it is necessary to show that the laser can be used successfully as a pump for wavelength conversion to the 8 Micron band. REF 2) The issue in that case is transverse mode beam quality.

Recent work on a compact CO2 laser module has been very promising in showing good extraction on weak lines. This work needs to be extended to sustained operation at high repetition rates (200 Hz or more). It is also necessary
to show good mode control, and to demonstrate efficient wavelength conversion with pump energies that are a factor of two reduced from the FAL case and with a substantially different temporal pulse profile. After these basic laboratory demonstrations, it will be necessary to reduce the size and weight of components that are the major contributors to the overall transmitter. The results of this effort will be applied in the near-term to the Artemis acquisition program to enhance the applicability of its chemical detection capabilities on the multiple platforms for which it is being developed.

PHASE I: Demonstrate a compact CO2 laser module at sustained high repetition rates on both weak and strong lines and tailor the output mode for pumping nonlinear crystals for wavelength shifting. This work will provide a data base for design of the fully capable testbed of Phase II.

PHASE II: Use the device of Phase I to demonstrate nonlinear wavelength shifting at high sustained repetition rates and reduce the size and weight of the major laser component. The Phase II work will result in a data base that can be used to design an integrated laser and sensor for deployment on the Artemis UAV platform and for other applications where size and weight are critical such as manportable sensors.

PHASE III DUAL USE APPLICATIONS: In Phase III, a prototype sensor system based on the compact transmitter can be built for standoff chemical detection field trials. If ongoing efforts to demonstrate biological agent detection with a CO2 laser operating in the 8-12 mm are successful, then the field trials could be expanded to include this important case. This would lead to a combined Artemis chemical and biological sensor suitable for deployment on a number of platforms. Development of such a sensor would be of great benefit in homeland defense applications and for environmental pollution monitoring.

OPERATING AND SUPPORT (O&S) COST REDUCTION (OSCR): Development of a compact standoff chemical sensor would greatly reduce the fabrication and logistics costs of presently conceived deployment systems. In the event that the sensor is capable of combined chemical and biological detection, operating costs could be further reduced. The compact sensor will be a capability that the Department of Army does not currently have and will represent a significant advancement in threat avoidance.

REFERENCES:

KEYWORDS: carbon dioxide laser, chemical detection, sensor, compact, UAV, 9P44, transverse mode beam quality

A04-142 TITLE: Development of a Fluorescence Lifetime Imaging System for Remote Sensing

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO, COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS

OBJECTIVE: The objective of this SBIR is to design and build a remote sensing system that records the fluorescence lifetimes (decays) of fluorophores indicative of threats to the warfighter. Preferably, this system could be used for airborne applications.

DESCRIPTION: Time-resolved fluorescence spectroscopy and fluorescence lifetime imaging microscopy (FLIM) are used to measure the intensity decays of fluorophores, otherwise known as their fluorescence lifetimes. Fluorescence lifetimes are typically measured in nanoseconds (ns) or picoseconds (ps), and can exist for both intrinsic and extrinsic fluorophores of both single- and multi-exponential decays. Time-resolved fluorescence adds a forth dimension (lifetime) to the steady-state fluorescence which includes excitation, emission and intensity components. The lifetime components of fluorophores, taken cumulatively, contribute to the overall steady-state
signature of a mixture. Fluorophores that have similar steady-state characteristics may have profoundly different lifetime characteristics and therefore can often be differentiated based on this (decay) feature.

Chemical and/or biological threats, or their indicators, that occur within the battlespace can potentially be separated and distinguished (from intrinsic background fluorescence or each other in the case of a mixture) based upon the component lifetimes, detectable by an instrument capable of measuring the respective decays of target fluorophores. For example, while reflectance measurements (multispectral and hyperspectral) and steady-state fluorescence show limited diagnostic change in vegetation canopy pigments related to specific stressors (e.g., defoliants, nerve agents), lifetime changes in photosystem pigments are more indicative of insults to the battlespace.

Imagery recording time-resolved data determines the degree to which multiple fluorophores contribute to the overall steady-state signature based upon component decay time. The components can reveal novel threats that typically possess some degree of fluorescent organics. Additionally, fluorescent labels and probes can be designed with unique steady-state characteristics as well as lifetimes for more confident detection and target confirmation.

Two approaches should be considered, integrating either an active or passive means of sensing. Lifetimes may be recorded using solar stimulated (excited) fluorescence as a passive approach, while laser-induced fluorescence should be considered representing a more traditional active approach.

PHASE I: Conduct a feasibility study on the design and development of a Fluorescence Lifetime Imaging System for remote sensing. Design a conceptual prototype suitable for field and/or airborne deployment.

PHASE II: Develop the prototype system from the Phase I effort, and demonstrate how fluorescence lifetime imaging can be integrated with remote sensing techniques. Test the prototype under a variety of controlled dispersals representing mixtures of intrinsic fluorophores and probes/sensors. Show how surrogate or indicator fluorescent compounds placed in the environment can be distinguished from intrinsic fluorophores, as well as from each other. Some examples include: fluorescent whitening agents - sewage pollution indicator; molecular imprinted polymers pre-designed to detect any number of compounds, such as dipicolinic acid (DPA)-Bacillus spore indicator. Interfering intrinsic sources of fluorescence could include humic substances and vegetation canopy. Another approach could involve investigating alterations in intrinsic environmental fluorescence due to the presence of an introduced stressor, such as changes in vegetation fluorescence due to the presence of heavy metals or pesticides. Establish limits of detection when ever applicable. Integrate global positioning with the unit for mapping and location of detected targets.

PHASE III: Such a device has broad dual use applications from environmental quality assessment to expanded military and intelligence community uses.

REFERENCES:

KEYWORDS: Fluorescence imagery, Lifetime, Steady-state, Remote sensing

A04-143  TITLE: Self Calibrating, Self Locating Seismic-Acoustic Sensor System

TECHNOLOGY AREAS: Battlespace

OBJECTIVE:
Develop algorithms and hardware for a portable distributed seismic-acoustic monitoring system consisting of wireless satellite sensing elements (SS) and a central acquisition and processing resource (CAPR). Such a system could be used for reliable wide area monitoring for a range of activities of interest to the DoD and Homeland Security. Activities include monitoring remote border areas, surveillance of military lines of communication, and forward deployment of sensors for situational understanding. All elements of the system should be hand deployable and operate without external power for at least 24 hours. Upon deployment and activation, the system should self organize (determine the locations of all sensors) and adapt to its unique geological and meteorological environment by estimating the seismic and acoustic signal-attenuation exponents. Robust and reliable system performance will be achieved through the large number of satellite sensors deployed (24) and their large separation (up to 50 m).

DESCRIPTION:
Unattended ground sensors (UGS) rely heavily on acoustic and seismic sensors (microphones and geophones) to track and identify threat vehicles in areas of military operations (Ref. 1). These systems generally consist of a single geophone and three to four microphones arranged in a circle with a diameter of 10 to 100 cm. Sound and ground-vibration data from the microphones and geophone are processed in a small on-board computer to calculate direction and range to a potential target, and to classify the target as a threat or non-threat. In an increasing number of widely publicized demonstrations, these systems are failing to meet threshold performance requirements (Ref. 2 and 3). These failures are directly attributable to the inability of such minimal systems to compensate for the complexity of the typical environment in which they are deployed or for variations in environmental conditions.

The keys to overcoming these failures are to electronically link several UGS and process the data from all of them coherently. The hurdle to coherently processed UGS data is the lack of a practical method to deploy sensors and transmit their data to a central processing computer. However, recent innovations in wireless communications (e.g., wireless computer peripherals and wireless networks) allow UGS to be untethered from their central data acquisition and processing computer. Automatic calibration, on deployment, of such a wirelessly linked array would provide information critical for threat vehicle identification and tracking: the location of each sensor, and the attenuation of acoustic and seismic signals in the air and ground (Ref. 4).

We propose development and demonstration of a system consisting of:
- 24 hand deployable satellite sensors
- One hand deployable central acquisition and processing resource
and having these core characteristics and functions:
- Automatic self organization (location of each SS relative to the CAPR) with accuracy of +/- 2.5 cm at SS distances at least 25 m from the CAPR.
- Absolute latitude-longitude location of the CAPR with accuracy of +/- 5m.
- Automatic determination of seismic and acoustic attenuation constants
- Wireless digital transmission of the full seismic and acoustic waveform from each SS to the CAPR on a 1 s interval. Each transmitted waveform will contain 1 s of data with 2000 samples at 16-bit digital resolution.
- Storage of all SS digital waveforms (seismic and acoustic data) on the CAPR with time registration (+/-0.0025 s) of each recorded waveform and association with its originating SS element.
- Continuous operation of the entire system for 24 hours on battery power.
- Ability to download raw seismic and acoustic data from the CAPR via standard 802.11 TCP/IP network.

PHASE I:
Theoretically determine the scientific and technical feasibility of producing such a system. Develop a breadboard design to demonstrate feasibility of the system.

PHASE II:
Demonstrate one prototype system consisting of 24 SS and one CAPR. The prototype will be finished and ready for production, hardened for field use in environments including hot and wet, hot and dry, cold and wet, cold and dry, dusty, and snowy.

PHASE III DUAL USE APPLICATIONS:
Produce, demonstrate and provide to the Government 3 fully operational systems. Demonstrate a network of all three systems by tracking a single target. Dual-use commercialization would be in municipal vehicle monitoring, counting and classification; secure wireless data transmission; distributed data processing; seismic exploration; non-intrusive measurement of ground properties for construction and mobility (depth to bedrock, ground water, thawed or frozen ground); measurement of noise and vibration fields around highways and industrial plants; monitoring approach routes to critical infrastructure such as electric generating stations, broadcast stations, remote border crossings, fuel storage facilities, pipelines.

REFERENCES:
KEYWORDS: UGS, unattended ground sensor, acoustic, seismic, self adaptation, attenuation, distributed

A04-144 TITLE: Self-Powered Sensors for Structural Assessment of Bridges

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of the research and development effort is to develop a structural capacity assessment system for bridges in the field that enhances current Military Load Classification capabilities. The bridges of interest are expected to be damaged or of unknown design. The field sensors will be self-powered, surface-mounted, capable of measuring strain (displacement), able to store data for a period of weeks to months, and able to periodically download data to an acquisition system. A sensor data analysis system will be developed that works with existing load classification analysis approaches to allow for faster and more accurate analysis of the load capacity of bridges in the field.
DESCRIPTION: Forward Engineering Support Teams (FEST) conduct Military Load Classification of Bridges in the field. These teams rapidly evaluate the ability of bridges to sustain loads, monitor loads and traffic, and make determinations of how much load can safely pass over bridges for military and emergency relief operations. Military convoys, mechanized vehicles, emergency relief personnel, and local residents depend on the speed and accuracy of the information provided. Bridges encountered may be heavily damaged and in almost every case, little will be known about the design and construction of the structure. It is obvious that the field evaluation of a bridge must result in a safe estimate of the load capacity of the bridge. However, it is also important that the load capacity calculation be correct, not unnecessarily conservative. This allows for maximizing traffic that is allowed to traverse a bridge and minimizing impact to operations or the community. In order to relax the conservatism of the structural analysis used to determine the safe loading for an unknown structure, it is necessary to know more about the structure.

Recent advances in measurement devices and materials now allow for enhancing field assessment of structures. This will ultimately allow for increasing allowable contingency loads on bridges analyzed in the field. Today, self-powered wireless sensors could be installed to acquire load versus displacement data for bridges and the information could be used to enhance the capability of field personnel to assess structures in the field. This system would have to be easily and rapidly installed, and capable of operating in most outdoor environments, be immediately operational, able to acquire data for some period of time (days to months), and be inexpensive. The system will require analysis software for interpretation of data to aid engineers in determining existing load classifications. This system will improve mobility decisions by reducing analysis time, improving safety (identifying structures that may be damaged or poorly constructed) and increasing allowable loads. The system also has the potential to provide continuous monitoring of changes in structural integrity of bridges and monitoring of traffic. Finally, it is desirable but not mandatory for the sensor systems to transmit data either continuously or in data dumps to the field data acquisition and analysis system.

PHASE I: Develop a strain sensor power generation and signal conditioning circuit and prove the concept. The sensor system must generate enough power to measure strain of a structural member under a controlled loading experiment and store data for a period of four weeks. The frequency response of the sensor system must be wide enough to experimentally demonstrate the capability for load conditions that would be associated with a bridge. Circuit designs will be tested and analyzed. Develop a concept for the rapid surface application of the self-powered system to typical structural elements. In summary, the sensor system must be capable of being rapidly installed for use in the field, inexpensive enough to leave in the field, and accurate enough to enhance analysis of the structure. A methodology for analysis of the data will be developed in sufficient detail to prove the ability to determine load classifications. The data analysis system must integrate with existing techniques for Military Load Classification of Bridges and enhance the understanding of the structure.

PHASE II: In Phase II, the efforts will involve the development of the overall system for the field. The selected Phase I sensor circuit design will be completed, an application system will be demonstrated, and the sensor system will be packaged in a weatherproof container capable of surviving at least four weeks in the field. Demonstrate the capability for acquiring data from the sensor system connected to a Personal Data Assistant, a laptop computer, etc. The container should have an active attachment capability detailed. Develop and demonstrate the analysis software for determining load classifications.

PHASE III: This system will be directly applicable to monitoring of bridges, operating heavy equipment, measuring - in a calibrated manner - loads crossing selected routes, and structural health monitoring, in general, of a variety of structures and facilities. It is desirable that in the future, the bridge sensors transmit data to the acquisition system and the proposer should give this challenge consideration.

REFERENCES:

KEYWORDS: structural monitoring, strain sensors, structural assessment, self-powered

A04-145 TITLE: Course-of-Action Forecasting

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: USAJFKSWCS Special Forces

OBJECTIVE: Develop a capability that can integrate temporal and spatial data from multiple sources, and then evaluate this data for historical patterns that may or may not be present. Identification of patterns, or behaviors, would then be used to predict future actions at specified spatial locations. In the development of this project, source material must be UNCLASSIFIED. Application of this software using varied sources would be feasible by a broader user community, thereby rendering this future software product adaptable to many levels of public safety.

DESCRIPTION: Intended agendas, or course-of-action plans of our adversaries may be hidden within myriad, seemingly unrelated information sources. These source materials may be internet URLs, e-mail message traffic, and/or internal reports. Source material is almost always dated, or time stamped, and this is critical for temporal analyses. Likewise, source data may be spatially enabled with a geographic location and if it is not, it can be linked to an X/Y coordinate via a gazetteer. Geographic information may be analyzed to evaluate patterns in space. The gist of this project is to conduct research on advanced methods for analyzing time and space together, with expectations for revealing patterns not detectable from either time or space alone. Traditional statistical techniques, such as trend analysis exist for temporal information. There is no accepted software for spatial trend analysis. Today, this is visually accomplished without the aid of a computer. Integration of the time- and space-stamped information is clearly a focus of this work. But most importantly, the research should develop an ability to integrate and analyze this historical time and space data so that we are able to predict our adversaries’ future course-of-action. The research is a form of advanced pattern recognition and dynamic interpretation with human decision patterns as its central driver. Testing and software model validation might best occur in a data-rich environment wherein hind-casting could be applied. Sample data sources representative of an operational scenario will be provided by the government. Use of this system should result in the ability to synthesize actionable intelligence. One of the critical applications of this research will be to provide a capability to analyze past, and forecast future, actions of terrorist activity.

PHASE I: Design and show feasibility for a software toolbox that has the ability to accept, integrate and evaluate temporal and spatial information from multiple diverse sources. Integration with ArcGIS software for the spatial mapping component of this work is encouraged.

PHASE II: Develop and demonstrate a prototype Course-of-Action Forecasting system. Demonstration should be validated by use of traditional hind-casting methods. Hind-casting compares known temporal and spatial outcomes with predicted outcomes by reserving the most recent time and space events for validation.

PHASE III: In addition to military operations and intelligence, uses of the product of this research could include homeland defense and emergency management. A Course-of-Action Forecasting system might be used for investigating and understanding of natural systems.

REFERENCES:

KEYWORDS: forecast, hind-cast, counter-terrorism, modeling, course of action, intelligence, military operations, actionable intelligence

A04-146 TITLE: Detector Array for Aerosol Particles

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Chemical-biological agents have potential for causing mass casualties. Defense against these agents requires early and continuous detection and unmanned operation so that protective action can be taken early. This solicitation seeks development of a small, lightweight, and inexpensive detector array for placement in building ventilation systems to detect bacterial endospores in the air. In particular, we seek to exploit laser scattering (angle-dependent intensity and angle-dependent polarization transformation) to develop a low-cost and low-maintenance early-warning trigger device. The use of angular light scattering and polarization to differentiate two similar bacterial spores was demonstrated by Bickel et al. (1976). The proposed trigger device could then initiate mitigation actions, such as “Electrokinetic Generation of Biocides” embedded in filters, as proposed by SBIR topic #A04-157 (V. Hock (217) 352-6511, with whom this has been coordinated), or more definitive analyses such as polymerase chain reaction (PCR) based protocols, which cannot operate continuously. This proposed topic complements, but does not duplicate, the Joint Biological Point Detection System (JBPDS), which relies on laser induced fluorescence to detect biological warfare agents.

DESCRIPTION: Existing detectors of bacterial agents require that sensors be placed at key locations to respond to agents being dispersed and drifting through the sensor volume. Small, inexpensive, robust sensor systems that are capable of being incorporated into building ventilation systems and are optimally tuned to characterize the type, size, and shape of aerosol particles and to detect deviations from normal are not available. Optical instruments exist for particle counting and sizing; however, high false alarm rates associated with counting and sizing alone makes them unsuitable for use as an early warning device. The high false alarm rate may be greatly reduced by measuring additional optical parameters such as angular scattering and polarization transformation. The system must have sufficient sensitivity to measure scattering from individual particles in the size range of approximately 0.5 um to 2.0 um among a range of common aerosol interferents, which may vary temporally in composition and concentration. The system should determine: 1) particle size, 2) particle shape, 3) particle concentration, and ideally, 4) particle composition. The sensor array may use multiple channels and variable wavelengths to characterize aerosol signature. Optimizing the sensor to detect bacterial spores and creating a site-specific database are critical to this approach. The proposed instrument will be used to develop a site-specific, self-updating database to characterize deviations from the normal aerosol signal.

PHASE I: Develop a breadboard model that will demonstrate the feasibility and capability of multi-detector arrays. The minimum proposed system should consist of a series of single laser wavelengths, simultaneous detection of the angular scattered laser energy at a sufficient number of angles to determine the scattering characteristics of the laser, and sufficient measurements to determine the degree of depolarization.

PHASE II: The prototype sensor should be demonstrated and provided to the government for testing. The prototype should be a finished, ready-for production product that includes multiple frequencies and can be placed in ventilation systems. The system should be able to operate in a wide range of environmental conditions typical of HVAC systems. The system should provide angular scattering and depolarization information for determining the scatter size, shape, concentration, and composition.

PHASE III: Phase three will expand on phase one and phase two efforts, potentially incorporating additional frequencies, optimized scatter angles, miniaturization, production-cost-reduction features, and have the potential of doing onboard processing to signal post sensor HVAC changes or further sensing. The final product should be a turnkey COTS device.
OBJECTIVE: The objective of this research is to develop and test biological warfare agent (BWA) countermeasures in Heating, Ventilation, and Air Conditioning (HVAC) systems for buildings at Army Installations using nanotechnology. A terrorist could release BWAs either externally or internally to Army buildings. Once the BWA infiltrates the HVAC system, the whole building is rapidly contaminated.

DESCRIPTION: The Department of Defense (DoD) is planning to install Chemical, Biological, and Radiological (CBR) sensors and response measures at multiple installations. Stand off detectors can increase the effectiveness of early warning of CBR hazards and assessing large areas for potential contamination, thus allowing the installation Commander to make rapid decisions on active defense, evacuation, shelter-in-place, and other countermeasures for military buildings. Installations need to detect and presumably identify BWAs as soon as possible to determine the appropriate countermeasures required to protect personnel.

PHASE I: The research will focus on determining the feasibility of using passive countermeasures to single small-scale release of BWAs, such as anthrax or smallpox, dispersed as a non-explosive point source, external or internal to buildings at Army installations. Passive countermeasures will involve the use of advanced technologies such as nanomaterials or dendrimers that can release neutralizing agents on demand to neutralize anthrax and smallpox. These materials could be integrated into liners or filter systems currently used in HVAC systems in Military buildings, where the BWAs will efficiently interact with neutralizing agents. Potential liner materials should be evaluated with respect to their potential to neutralize BWA simulants.

PHASE II: Test and demonstrate the countermeasures using nanomaterials or dendrimers in building HVAC systems to enhance their immunity to BWAs that can be released externally or internally. The countermeasures should be capable of releasing neutralizing agents on demand at simulated BWA dosages equivalent to minimum infection levels (e.g. 4000 spores for anthrax). Characterize the effectiveness of the countermeasure technology using simulants for the BWAs (such as bacillus globulii for anthrax, and vaccinia virus for smallpox), by counting colonies or spores remaining on random samples of BWA harvested from liners and filters in HVAC systems exposed to the countermeasures. Target kill ratios to be achieved by the neutralizing agents should be at least 100 to 1.

PHASE III: The Department of Homeland Security (DHS) is installing BWA sensors around population centers. Military and Civilian buildings will be far less attractive targets to terrorists by airborne aerosolized biological warfare agents, if passive countermeasures are installed to make the buildings immune.

REFERENCES:
A04-148  TITLE: Remote Acoustical Reconstruction of Cave and Pipe Geometries

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: Develop an acoustical reflectometry technique for imaging the geometry of tunnels, caves, piping, ventilation ducts, and other corridors of varying cross section. The technique must not require direct human entry of the corridor.

DESCRIPTION: Tunnels, caves, piping, and ducts are common features of complex terrain and urban environments. Such corridors have a high military significance as they provide opportunities for concealment of enemy combatants and materiel. But direct human entry into these corridors is often highly dangerous or infeasible, due to the possible presence of explosive devices or hidden personnel, or to natural or manmade obstacles that limit accessibility. Therefore, robust techniques for determination of the shape and dimensions of unfamiliar passages at a safe stand-off distance is highly desirable. Robotic and imaging technologies have not generally reached a maturity level where unmanned exploration is feasible or can be undertaken at a reasonable cost.

A viable alternative to direct entry by a human or robotic probe, which has been demonstrated in other contexts (such as imaging of the human larynx and lung, see references below), is acoustical reflectometry. This technique makes use of the reflections occurring at changes, gradual or sudden, in the cross section or wall properties of a tunnel/cave/pipe/duct (“waveguide”). An acoustic source is positioned near the entrance of the waveguide and the time series of the reflections is recorded and analyzed. A mathematical relationship exists between the time-history of the reflected waveform and the acoustical impedance of the waveguide as a function of the distance from the opening. This relationship allows determination of the lengths and size of corridors, as well as the presence of branches, blockages, or vents.

PHASE I: One or more experiments to determine the feasibility of acoustical reflectometry of tunnels/caves/pipes will be performed. Appropriate probing source signals will be devised. Reflected signals will be inverted to determine the cross section and other geometric features of the tunnel/cave/pipe as a function of distance into the cave. These reconstructions will be compared with ground truth. A report will be prepared describing the results of the experiments and the techniques used in the reconstructions.

PHASE II: A prototype system will be developed consisting of an appropriate sound source, signal processing capability, mathematical inversion technique, and a real-time graphical display of the reconstructed tunnel/cave/pipe geometry. The system will be demonstrated on tunnel/cave/pipe features in geologically complex and urban terrains. Recommendations will be developed for successful application of acoustical reflectometry to situations of Army tactical interest. Limitations on the ability to image complex cave systems will be examined and documented.

PHASE III DUAL USE APPLICATIONS: This SBIR will lead to a portable system for safely determining the geometrical properties and potential militarily significance of cave complexes and underground urban tunnels. Commercial civilian applications include imaging of inaccessible caves and emergency imaging of partially collapsed mine shafts. It also could potentially be used in emergency situations to identify air pockets (and therefore survivor locations) in urban structures that have collapsed from earthquakes or terrorist activities.

REFERENCES:

KEYWORDS: urban and complex terrain, stand-off ISR, UGS, acoustics
TITLE: Electrokinetic Soil Stabilization for Rapid Construction

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: The objective of this topic call is to develop a rapid soil stabilization mechanism utilizing electrokinetics to: 1) dewater potential airstrips and construction sites, 2) improve the shear strength of soft sensitive clays, and 3) deliver chemical compounds to increase the shear strength of soils.

DESCRIPTION: Today's Military must develop the flexibility to rapidly respond to regional deployment requirements. Chief among these is the rapid projection of air power. Fixed wing aircraft and landing strips for them are current requirements for larger scale troop movements. When airfields need improvement or when they are not present, they must be constructed in a timely fashion with some independence of the local terrain. Thus there is a need for the rapid construction and repair of runways. ElectroOsmosis and electrokinetic migration of chemicals can be used as mechanisms to stabilize and strengthen soil and clays for both rapid airfield construction and general soil foundation stabilization.

PHASE I: Phase I work will focus on a novel, rapid soil stabilization system incorporating electrokinetic principles to rapidly improve the shear strength and bearing capacity of clays. Phase I will be a laboratory scale proof of concept focusing on using electrokinetics (EK) as a driving force to deliver ionic (or polar) chemical stabilization compounds in clay. Potential systems include (but are not limited to) cementitious co-compounds, chemical species that directly modify the clay itself, or taking advantage of secondary EK effects such as changes in pH to modify clay or drive additional reactions.

PHASE II: The product of Phase II work will be to scale up the Phase I laboratory prototype system, and quantify and improve the power efficiency. This field scale trial will be evaluated for potential use in the rapid construction of military runways, roads and forward facilities.

PHASE III: This technology has the potential to stabilize soils supporting: the rapid construction of foundations for airfields, pavements, and forward facilities. The same techniques can also be extended to the private sector to reduce construction times by dewatering construction pits. Perhaps most importantly, the technology could also be used to stabilize expansive soils supporting foundations in order to prevent structural damage.

REFERENCES:
1) Summary of Soil Stabilization Processes: Electrical Stabilization of Fine-Grained Soils. Miscellaneous Paper No. 3-122. US Army Engineer Waterways Experiment Station, Corps of Engineers, Vicksburg, MS.
2) Yalcin B. Acar, Robert J. Hamed, Gregg Putnam, Acid Base Distributions in Electrokinetic Soil Processing, Transportation Research Record, 1288.
A04-150  TITLE: Electrokinetic Generation of Biocides for Advanced Air and Water Filtration to Mitigate Biological Threats

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective of this topic call is to develop an advanced air filtration unit capable of destroying biological agents by employing an electrokinetically driven countermeasure. This countermeasure could be activated automatically by a biological or chemical agent sensor similar to the one proposed in Army SBIR Topic, entitled “Detector Array for Aerosol Particles,” Topic Author: Charles Reynolds Phone: (603) 646-4394.

DESCRIPTION: Current air filtration methods are very restrictive to airflow, thus there is a high operational energy cost for high efficiency filtration. A new approach is required for a filtration system which is both less restrictive to airflow and capable of incapacitating airborne biological agents. This topic focuses on using electrokinetic reaction byproducts as a kill mechanism on a filtration surface.

PHASE I: The product of Phase I research will be to develop a prototype filtration media functioning as an electrically activated biological countermeasure. The goal is to prevent biological agents from entering an HVAC (Heating Ventilation and Air Conditioning) system without using filtration systems that are highly restrictive to flow. The countermeasure will be activated by applying a distributed electrical potential across the medium. The electric field will drive an electrokinetic process that generates a sanitizing agent on the filtration surface. The Phase I work should focus on the development of a system to generate concentrations of ionic compounds sufficient to effect a five log kill rate. Concentration requirements for achieving this rate are present in the literature, and this Phase I topic does not require work with live agents. Successful completion of Phase I will be demonstrated by showing the necessary concentration of ionic species generated at the prototype filter surface (e.g., Ag++, Cu++, ClO2, etc.).

PHASE II: The product of Phase II work will be to measure and refine the prototype system kinetics. In order to be a truly effective countermeasure, the system must be fully active in 5 to 10 seconds. To achieve this benchmark, the system kinetics will be optimized in Phase II.

PHASE III: Commercial applications of this technology could be extended to industrial, pharmaceutical, and any large building HVAC systems to increase the security of air delivery.

REFERENCES:
3) Lawrence Berkeley National Laboratory (LBNL) Berkeley, CA; COMIS Multizone Air Flow Model.
4) Philip S. Stewart, Wanida Wattanakaroon, Lu Goodrum, Susana M. Fortun, and Bruce R. McLeod, Electrolytic Generation of Oxygen Partially Explains Electrical Enhancement of Tobramycin Efficacy against Pseudomonas aeruginosa Biofilm, Center for Biofilm Engineering, Department of Chemical Engineering, and Department of Electrical Engineering, Montana State University Bozeman, Bozeman, Montana.

KEYWORDS: Biological Countermeasure, Heating Ventilation and Air Conditioning (HVAC)

A04-151  TITLE: GeoText

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: USAJFKSWCS [Special Forces]
OBJECTIVE: The purpose of this effort is to develop a complete geographic text processing system for tagging place names in text files and spatially visualizing the results. This will require three operations: 1) automatic recognition and tagging of geographic names in text files, 2) interactive editing of the tagged text files, and 3) synchronized visualization of the text with a map display. These capabilities will be offered as a standalone system and a web service.

DESCRIPTION: It is estimated that 80% of government data contains spatial reference information in the form of addresses, place names, or coordinates. While some of this information exists in spatial databases, which are structured for use with geographic information systems, most of the information exists in unstructured text files. In order to support spatial analysis of text sources, structured text files with place name tags, containing or referencing coordinate information, are required.

While tools exist for automatically identifying place names in text, this effort focuses on significantly improving the current capabilities within the context of an end-to-end system. The system will include functionality for automated tagging, interactive editing, and visualization.

Geographic text tags will include explicit spatial references or references to features in gazetteers or other spatial databases. Tags should support multiple spatial representations of the associated geographic features and may appear as points, lines, or areas, depending on the scale of the visualization. The tagged and structured text will be available for search and analysis by other applications or direct visualization.

Automated, geographic text recognition requires advanced natural language processing, including lexical and spatial contextual analysis. Current accuracy rates, which range from around 65%-90% (depending on the source material), need to be improved. The output of automated geographic text analysis is 'dirty geotext' document. It is considered 'dirty geotext' because multiple results may be identified, text may be tagged incorrectly (Washington in the name George Washington), or text may not be tagged.

An intelligent, interactive editing capability is needed to process 'dirty geotext' to create correctly tagged 'clean geotext'. Tools will be needed to add, modify, or delete tags. Given the labor-intensive nature of this task, agents will be required to provide intelligent guesses to facilitate the process, while providing the option for full manual entry.

As envisioned, there will be two classes of documents in the future: 'dirty geotext' that has undergone automated processing and is known to contain errors and 'clean geotext' that is certified error-free. Documents will include metadata describing the tagging process and estimated accuracy.

Visualization of geotext will complete the required geotext handling capabilities. The user should be able to view the text document, while seeing the associated geographic features drawn on a synchronized map display. The user should be able to highlight a name, block of text, or the entire document and see the associated features drawn on a map. The map elements and extent will be determined by the contents and context of the selected text.

PHASE I: Phase I will include the design of a structure and format for tagging place names in text files. In addition, basic tools will be developed to automatically tag place name information in text files, interactively edit the tagged files, and display the tagged text and associated map. Tagged files with explicit coordinates, links to gazetteers, and links to spatial databases for point features will be demonstrated. The tools may operate independently in standalone mode.

PHASE II: Phase II will demonstrate integrated automated tagging, interactive editing, and visualization capabilities. Tagged files with explicit coordinates, links to gazetteers, and links to spatial databases for point, line and area features will be demonstrated. Tags supporting links to multiple feature representations will be demonstrated. The tools will operate in both standalone and web service mode.

PHASE III: This development would have significant commercialization potential for non-Federal government organizations, which have significant holdings with spatial text, and within the commercial electronic publishing market. It represents an innovative, value-added, information-rich enhancement to existing text documents.
REFERENCES:

KEYWORDS: geotext, geographic visualization, gazetteer, map, geography markup language, extensible markup language, gml, xml

A04-152 TITLE: Soil Imaging System

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: PEO, COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS

OBJECTIVE: The objective of this research is to develop a technology suitable for accurate and automated insitu identification of Universal Soil Classification System (USCS) soil texture types using advanced imaging technology. Soil texture is crucial to site suitability, mobility, counter-mine, and engineering applications. The technology to be researched and developed should include both hardware and software elements for rapid automated identification.

DESCRIPTION: The product of this research should be a system composed of both hardware and software components that accurately measures soil in the field and assigns the measured soil to one of 17 USCS soil types. It is anticipated that measurement and depiction of soil particle size and color would occur at user-defined incremental depths between zero and one meter and be used as the metric for assignment into one the USCS soil types. Hardware and software selected, or built, and the method by which a soil type is automatically assigned to a USCS soil type, constitutes the research and development for this project. No system exists that quickly, efficiently, and accurately classifies soil into a USCS schema. Although this capability is envisioned as a below-the-surface measuring system, it is possible that hardware and software could benefit from developments in spectral- and radar-based above-ground image acquisition and analysis. It is anticipated that the developed system would employ an optical view of the below-ground soil combined with an automated analysis of the image for purposes of USCS classification. However, other imaging methods may be possible and should not be ruled out if research indicates their ability to produce the desired accurate and automated assignment into USCS soil types. A suitable ground vehicle-based sensor delivery system should be conceptualized and demonstrated in a proof-of-concept operation by the contractor. It would be desirable if one version of this delivery system could be mounted on an all-terrain-vehicle, allowing the system to be used in otherwise difficult-to-navigate terrain. Data output should be in Army GIS-compliant format, tagged with a geographic position, and capable of wireless transmission and encryption. In addition to soil texture, other properties that might be collected at the same time and place with the system could
include soil moisture and compaction (pounds per square inch). Reference to automation is intended primarily to apply to the acquisition and processing of soil texture and other properties without having to extract core samples for laboratory or detailed field analysis. However, robotic vehicles for delivery of the system to field locations are not included in the scope of this effort. Soil samples may need to be acquired along transects that will be used in conjunction with remotely acquired soil property estimation techniques. As an example, possible use of the soil texture data would be used as input to initialize larger area heuristic soil texture models and root-zone-level water balance exchange models (soil-vegetation-atmospheric-transfer models).

PHASE I: Develop conceptual design and show feasibility for Soil Imaging System, to include imaging sensor to be used, software required, and the vehicle delivery system for its deployment. Feasibility should include examination of automated algorithm extraction of soil texture categories.

PHASE II: Develop and demonstrate an integrated prototype Soil Imaging System in varying soil texture environments. Demonstrate accuracy of the system by comparing results with traditional methods of laboratory and detailed field analysis.

PHASE III: In addition to military battlespace and installation applications, this product should find wide application in agriculture, resource management, archeology, and engineering.

REFERENCES:
1) Land delivery versus airborne due to the “lack of a model for interpreting data from an instrumented ballistic probe that can be launched into a remote site.” Accordingly, ERDC’s AT22 work unit, Soil Properties from Low Velocity Probe Penetration, is under investigation by CRREL/GSL at the 6.1-level funded for FY03-05.

KEYWORDS: soil, soil texture, imaging, all terrain vehicle, algorithms, image processing

A04-153 TITLE: Scalable Wireless Geo-Telemetry Capability for Miniature Smart Sensors

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO, COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS (}

OBJECTIVE: To develop a modular, small, self-sufficient, low cost, and scalable wireless communication and positioning (geo-telemetry) capability for miniature smart sensors, such as those monitoring environmental variables and conditions. The development will include integrating data from a randomly dispersed mixture of miniature smart sensors within a Geographic Information Systems (GIS) for self-mapping and data generation.

DESCRIPTION: Technology has seen rapid developments in GIS, wireless communication, Global Positioning System (GPS) components, and miniature sensor detection devices. This proposal seeks to integrate these advances within a geographic information system (GIS) framework. The goal is a miniature, low cost wireless communication and GPS capability (geo-telemetry) that transmits data, including event, time and location, from a mesh network of mixed miniature sensors. (Telemetry is the automatic measurement and transmission of data from remote sources by wire, radio or other means. The data transmitted in telemetry normally does not have a location component. Geo-telemetry adds spatial or location information to measured and transmitted data.)
Remotely deployed, self-sufficient, and miniature smart sensor devices are essential for the Future Force. Such sensors extend situational awareness in denied or high-risk areas by providing early warning and assessment of threats. With this situational awareness, economy of force and force protection are facilitated. Recent research in sensor technology shows potential for “chip” sensors, or miniature smart sensors, tailored to specific chemical compounds or biologic agents. Being the size of a dime, these miniature sensors must: 1) communicate data without a cumbersome infrastructure; 2) be self-sufficient – existing in the field for a considerable amount of time independent of maintenance (e.g., long battery life); 3) be easily distributed; 4) maintain minimal physical footprint; and 5) transmit basic information tagged with accurate location and time data when a presence or ‘hit’ is detected – i.e., provide geo-telemetry.

Advances in wireless communication allow greater autonomy of movement and placement of miniature sensors that further extend the tactical reach for battlefield assessment. However, accurate geo-positioning (GPS) information, integrated within the miniature footprint of the sensor and wireless communication capability, does not currently exist. Further, GIS self-mapping and data generation tools exist but need refinement.

The Government seeks a contractor to investigate methods and hardware to implement a miniature wireless communication and GPS (i.e., geo-telemetry) capability for remotely placed miniature smart sensors, as well as the software to spatially integrate the data automatically into a GIS. The capability must include precise position location and time solutions (GPS) while supporting wireless environments. Ultimately, the geo-telemetry capability must exhibit a small footprint, low capital and operating costs, minimal infrastructure, simple operation, low energy consumption, minimal monitoring and maintenance, long unattended life, and self-sufficiency. The GIS software must be capable of dynamically and spatially locating the remotely placed sensors within terrain databases, and meet the latest standards for open system interoperability and use in Army systems.

The Government envisions a flexible and modular communication and geo-positioning capability that can be integrated with dissimilar measuring or detection sensors (e.g., smart sensors, target detection devices, and meteorological sensors). There is an ever-burgeoning suite of miniature sensors that are new – many not currently available. Also, miniature sensors are being designed to replace currently fielded sensors that do not lend themselves to remote deployment. The geo-telemetry capability is applicable to many of these. Further, the wireless geo-telemetry capability could be coupled to a miniature sensor that is attached to a product or physical asset (e.g., person, vehicle) whether moving or static, thus the need for a dynamic spatial mapping in some cases.

This program will leverage sensor technology research and COTS networking capability with state-of-the-art wireless communication and geo-positioning (GPS Chip) technology. By taking advantage of COTS networking and antenna technology, as well as on-going research, the government ultimately envisions communication between distributed sensors (peers), and from source to destination employing multiple hops (chain of communication) in order to expand the distances of sensor distribution. Similarly, this program will leverage COTS GIS for dynamic mapping and data generation.

Different sensors communicate different quantities of information, with some sensors requiring a more robust capability, whereas some a less robust capability. For this solicitation, the government envisions those sensors with lower bandwidth requirements.

By exploiting each sensor’s unique capabilities, and coupling them to an appropriate miniature wireless communication and geo-positioning (geo-telemetry) capability, an ad hoc mesh network of miniature sensors could be designed and easily deployed for specific needs. The wireless geo-telemetry capability could communicate a continuous flow of real-time information from a single sensor or a mesh of sensors. Or, the devices might be “dormant”, designed to simply turn on to transmit a “detect” or to relay data, then turn off again to prolong its field independence (lower power and bandwidth) and stealth. The inherent GPS capability will facilitate rapid deployment by ground or aerial means.

This capability shall be implemented in a manner to facilitate both commercial uses and Government uses such as Homeland Defense, Army Future Combat Systems, and the Environmental Protection Agency Programs. This capability supports the Geospatial Information Integration and Generation Tools (GIIGT) STO that in turn supports the Army’s Future Combat Systems (FCS) through the Battlefield Terrain Reasoning and Awareness (BTRA) STO.
For activities that tend to take place over wide geographical areas, such as battlefields, agriculture areas, mining districts, oil fields, refineries, and resource management areas, and for use in environmental monitoring and security, randomly distributed remote smart sensors could monitor critical conditions and events. With self-sufficient independent sensors efficiently communicating data, position and time, notice could be transmitted on movement, presence, malfunction, or out of spec, and perhaps even report on a specific problem or presence of a chemical or biologic agent.

PHASE I: Project feasibility and breadboard implementation: The contractor will accomplish the following research goals: 1) develop and show feasibility of miniature wireless communication and geo-positioning (GPS) capability, and 2) integrate key components and relationships in a breadboard implementation by utilizing an example sensor. To demonstrate system feasibility, the contractor will demonstrate the wireless communication of spatial and sensor data and provide a report documenting the design and prototype specifications.

PHASE II: Development and demonstration: The contractor shall develop and deliver prototype wireless communication and geo-positioning hardware and software system that interoperates with various sensors and COTS geographic information system (GIS). The contractor will demonstrate the ability to disperse a mesh of miniature smart sensors, model/display that distribution within a GIS, demonstrate the communication between and amongst the sensors and a support center, and demonstrate self-sufficiency (e.g., long-life power).

PHASE III: This SBIR would result in a technology with broad applications in the civil and military communities by providing a capability to distribute relatively small, independent, self sufficient wireless communication and geo-positioning units for integration with various tailored chip sensors. The techniques proposed in this SBIR will provide terrain information systems, such as the Combat Terrain Information Systems (CTIS) with sensor communication software, and therefore enable these systems to produce products to help the battlefield commander make better real-time and near real-time decisions. For the commercial sector, the new technology would allow for the placement and distribution of various sensors to be integrated into any number of applications.

REFERENCES:
An object of research is to develop a low-cost kinetic energy interceptor guidance and control technique that substantially reduces the cost per kill for RAM and UAV engagements over conventional guidance approaches. The guidance technique will likely fall within one of the four traditional interceptor approaches identified above but will need to utilize low-cost missile sensors that replace expensive missile sensors and maintain minimal impact on fire control resources.

Technologies, such as unitized manufacture of RF seeker and components using Micro/Milli-meter wave Monolithic Integrated Circuit (MIMIC) and microstripline technologies, are the driver(s) to lower seeker cost(s) and size with cost goal of $5K per interceptor. Seekers based on this technology should be able to attain probability of detections in the range of 90% or better at ranges of about 50 to 5000 meters. Single shot engagement kill probabilities should be 80% or better.

PHASE I: Develop a guidance and control technique for a low-cost per kill fire control sensor/interceptor architecture including identification of the hardware components required for implementation. Use analysis and simulation to illustrate and quantify performance of proposed approaches.
Leverage MIMIC and microstripline technologies, if possible, to reduce implementation cost(s). Produce a budget of error sources that impact miss distance and perform a sensitivity analysis to assess critical sources of error. Address other performance issues that are unique to the architecture.

PHASE II: Fabricate and demonstrate samples of the critical components of the selected Phase I guidance and control architecture. Combine demonstrated results with analysis and simulation to illustrate the impact of error sources on miss distance and assess cost per kill for the RAM and UAV threats.

PHASE III: The technology developed under this effort has dual use and is directly applicable to a broad range of military and civilian applications where low cost guidance and control is required. Examples of potential applications are low cost precision point-to-point navigation or automated landing systems for unmanned vehicles. Low cost of this guidance technology will increase the opportunities for dual use applications.

REFERENCES:

KEYWORDS: Guidance and Control, Fire Control, Kinetic Energy Interceptor

A04-155 TITLE: Low Cost Adaptive/Programmable Waveform Generator

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Design, build and evaluate a low cost, light-weight device that is capable of generating a specified waveform in the time domain given the desired waveform characteristics in the frequency domain such that they can be programmed into the device. The resulting time domain waveform must exhibit all frequency domain characteristics specified. The device should be suitable for use in Real Time Simulator (RTS) systems that cover frequency bands from UHF to W-band.

DESCRIPTION: Hardware in the Loop (HWIL) systems use a substantial number of waveform generators for evaluating and assessing the performance of a significant number of sensors that utilize a variety of waveforms over a number of RF bands. Current devices are costly and introduce errors, such as quantization errors, offset errors, linearity errors, scale factor errors, and non-monotonic behavior. Consequently, there is a need for a device that is at least an order of magnitude less costly than current devices such as Direct Digital Synthesizers and Digital RF Memories and that can eliminate or reduce the effect of errors.

Future Combat Systems, with a variety of sensors and communication systems, are difficult to simulate because of the huge number of waveform generators needed to execute meaningful Hardware in the Loop (HWIL) simulations because of the cost and diversity of waveforms needed. Other systems, such as Common Missile, that employ more than one sensor, need to be simulated to evaluate their performance potential as well as to predict performance. Again, cost and diversity of waveforms affect the capability to execute creditable simulations. Diversity of waveforms is, of itself, not a limiting factor. Rather, it is the cost associated with the generation of numerous waveforms that is a driver.

The mathematics from which current waveform generation schemes are devised are well established. However, to avoid the errors associated with digitization, the mathematics to formally establish a new design approach may need to be modified/adapted for a new design approach or the mathematics may need to be extended to introduce new waveform generation concepts.

PHASE I: Develop a preliminary design for the device and evaluate the feasibility for use in RTS systems. Feasibility may be demonstrated using a Linear Frequency Modulated (LFM) waveform as a baseline waveform. Analysis should show how the design can be extended to other waveforms. Analysis may include a digital
simulation of the design such that a LFM waveform for example may be generated at the output of the device given a specified set of characteristics for the waveform in the frequency domain. The results of the analysis should be sufficient to fully evaluate and analyze the device’s performance and its capabilities for extension to other waveforms. Any limitations and/or constraints that affect the performance of the device or its extension to other waveforms should be identified and explained. A major goal is to show that the cost of the device does not exceed $20,000 with a cost goal of $10,000. In addition, military and commercial applications of the device will be assessed and a detailed plan for militarization and commercialization will be prepared.

PHASE II: If the respondent is successful in demonstrating that the requirements of Phase I have been achieved, the respondent will design and build a prototype device operating within an RF band to be specified during Phase I and being capable of generating a minimum of three different waveforms with specified characteristics in the frequency domain. The respondent will demonstrate the performance of the prototype device and analyze the performance results in an environment or system to be specified during Phase I.

PHASE III: If the prototype is successfully built and demonstrated, there would be significant interest in the military for adapting the technology to numerous systems such as missile systems, air defense systems, ECM/ECCM systems, synthetic aperture radar (SAR) systems. Commercially, there would be interest by law enforcement agencies for countering communications used in criminal activities such as drug trafficking.

REFERENCES:

KEYWORDS: Sensors, Radar, Waveform Generation, Simulation, Counter-Measures

A04-156 TITLE: On-Demand Gas Generator with Real-Time, Open-Loop Control System for Gel Propulsion

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PM Common Missile

OBJECTIVE: Develop and build a compact, light on-demand gas generator with an open loop dynamically updated control system that can maintain the pressure driving gel propellant pistons within 3%.

DESCRIPTION: The current baseline pressurization system for gel propulsion is a gas generator that utilizes individual, solid grains that are fired sequentially when the driving pressure drops below a set value. This topic is to develop an alternate approach to pressurizing gel propellant pistons: a two stage bootstrap on-demand gas generator. This concept uses a monopropellant or bipropellant gas generator that maintains the pressure driving the gel propellant pistons within 3%. A squib provides sufficient pressure to start the first stage of the gas generator by pushing a small amount of monopropellant into the catalyst bed or the fuel and oxidizer propellants in a small combustion chamber to provide the pressure to drive the propellants into a second, larger stage that provides the pressure to drive the gel propellant pistons. The pressure downstream of the second stage is fed behind the piston or pistons of the first stage. The first stage piston or pistons have a larger area exposed to the gas than the propellant, providing a mechanical force amplifier. The process is regulated with an open loop, dynamically updated thermal pressure model. The propellants would ideally be gelled, however, liquid propellants would be acceptable.
PHASE I: Develop a compact on-demand gas generator design that would provide sufficient capability to drive a 7 inch diameter gel propulsion system. The pulse duty cycle would be approximately 10 percent of the 2 minute operation time. This design must include thermal, structural, and material compatibility considerations to identify the critical parameters driving the design.

PHASE II: Fabricate and demonstrate a heavyweight on-demand gas generator prototype using the pulse duty cycle defined in Phase I. The test plan should map out all the critical performance variables including an operating temperature range of -40 degrees Celsius to +45 degrees Celsius. The capability of the heavyweight design will be verified with hot-fire test series of a well characterized gel propulsion engine. An existing model/pressure control algorithm will be provided as a starting point for the development of the generator's control system. The contractor will be responsible for improving and incorporating this algorithm. The end result of this test series will be a heavyweight on-demand gas generator prototype that has been tested in a realistic environment.

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

REFERENCES:

KEYWORDS: on-demand gas generator, warm gas generator, propellant expulsion, monopropellants, bipropellants, engine testing

A04-157 TITLe: Protective Coating for ZnS Windows & Domes

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Joint Common Missile

OBJECTIVE: Develop a protective coating for ZnS domes and windows with the strength comparable to AlON or Spinel and the transmission characteristics of multispectral ZnS.

DESCRIPTION: The U.S. Army Aviation & Missile Research, Development, and Engineering Center is involved in a number of missile dome and window projects where ZnS would be an attractive candidate due to its extended transmission window. The most serious drawback to ZnS is that it is a relatively soft material. AlON, Spinel, and Sapphire all have considerable mechanical strength and erosion advantages over ZnS but all are limited in their useable wavelength ranges. Seekers currently in the planning stage will require domes and windows that transmit in the visible, at laser designator wavelengths in the near infrared, an extended midwave infrared region, and into the long wave infrared regime. The purpose of this task is to develop a protective coating for ZnS that would provide the same erosion resistance as AlON or Spinel without seriously degrading the transmission characteristics of the ZnS substrate.

PHASE I: Phase I would investigate the feasibility of developing a erosion protection coating for ZnS with the durability of AlON and without significantly degrading the transmission characteristics of the substrate. The research plan should clearly describe the materials to be investigated and any associated risk factors. Thermal environment limitations of the coatings should also be addressed. Potential systems that might use such a coating include Common Missile and THAAD. Candidate coatings must survive the thermal shock environments associated with both missile types.
PHASE II: The goal of Phase II is to develop the most promising coating or coatings investigated in Phase I. It is anticipated that Phase II would address coating both ZnS windows and large hemispherical domes (approximately 7" diameter). Coated samples of both may be required for Government sponsored wind tunnel thermal and erosion testing.

PHASE III DUAL USE APPLICATIONS: The goal of Phase III is to scale the process to a production capability and to investigate the protective coating on additional materials of interest. Additional applications for other DoD agencies will also be investigated.

REFERENCES:

KEYWORDS: coating, infrared, ZnS, erosion resistance, dome, window

A04-158 TITLE: Unmanned Air Vehicles Diagnostics/Prognostics

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Comanche

OBJECTIVE: Develop an Integrated Diagnostics/Prognostics system that can improve affordability, survivability and service life of Unmanned Air Vehicles.

DESCRIPTION: The goal of this venture is to improve the affordability, survivability and service life of Unmanned Air Vehicles (UAV) through the use of an integrated diagnostics/prognostics system. The system will be used in real-time to obtain structural diagnostic information on the UAV and transfer this information to prognostic models that can monitor its operational capability and/or its useful service life. The proposed system should utilize advanced sensor suites, on-board data processing, materials failure models, and wireless communication to achieve a low-cost, autonomous solution for prognostics and diagnostics. Embedded sensors and control elements could monitor critical parameters and the resultant data collected, stored and analyzed by on-board processors to detect and diagnose problems, failures and battle damages. Using this information, the UAV may reconfigure itself to mitigate the problem or operate in a degraded mode, which will allow the completion of the mission and/or survival of the UAV.

PHASE I: Develop a concept for the integrated diagnostics/prognostics system for UAV and investigate sensor/sensor suites and failure models that can be used to prove system feasibility. Develop system design and framework for interaction between diagnostic information and failure models.

PHASE II: Develop a prototype of the integrated diagnostics/prognostics system. Use existing failure models or establish new ones to achieve the goals outlined above. Interaction with UAV manufacturers is recommended. Develop appropriate hardware and software for analysis, interpretation and transfer of diagnostic/prognostic information. Demonstrate and validate the developed system on a UAV component.

PHASE III: Work with UAV contractor and Army to validate the integrated diagnostics/prognostics system and implement it on UAV structures. UAV prognostics/diagnostics advancements in condition monitoring technology contribute to the Revolution in Military Logistics, whereby the Army will reap enormous benefits in streamlined maintenance, efficient supply, lower operating and support costs, and assured effectiveness. The diagnostic imaging tools system can potentially be used for structural condition monitoring of any type of structures used in aircraft, ships, spacecraft and automobiles.

REFERENCES:
4) “Prognostic Enhancements to Diagnostic Systems for Improved Condition- Based Maintenance”, Byington, Carl S.; Roemer, Michael J.; Kacprzynski, Gregory J.; Galie, Thomas, Contract Number: N000167-01-C-0064, 2002.

KEYWORDS: sensors, sensor suite, diagnostic, prognosis, unmanned air vehicles

A04-159 TITLE: Innovative and Cost Effective Obstacle Avoidance/Navigation for Small Tactical Unmanned Aerial Vehicles (UAVs)
TECHNOLOGY AREAS: Sensors
ACQUISITION PROGRAM: PM UAV Systems

OBJECTIVE: Leverage advances in integrated circuits, sensors, and communications to enable small UAVs to operate in the same airspace with both manned vehicles and other UAVs.

DESCRIPTION: Collision avoidance capabilities (“see and avoid”) are essential for UAVs to operate in the National Airspace System (NAS) in proximity to manned aircraft and possibly other UAVs [1,2]. Although small UAVS are being considered for numerous military and civilian applications, there is a need for collision avoidance systems analogous to what exists for manned aircraft. This would also allow small UAVs to fly in formation as autonomous networks, enabling a swarm of UAVs to be used for communication relays (such as transmitting surveillance data), delivering lethal payloads, and other functions [3,4,5,6]. This SBIR solicitation seeks to complement and augment efforts by DARPA [7], ONR [8], USAF, and other organizations seeking UAV autonomous collision avoidance systems. For example, a key characteristic of DARPA’s organic air vehicle (OAV) program is a “perch and stare” capability, which cannot be realized without sophisticated obstacle avoidance technologies. Recently, NASA’s Environmental Research Aircraft and Sensor technology program demonstrated an experimental radar (35 GHz) flying on the Proteus UAV (pilot on board during tests). However, small UAVs pose many different constraints [9], such as flying close to the ground, and limited power and available space for system components and on-board processing. In the recent past [10], research in collision avoidance leveraged techniques in image processing developed by the automobile industry [11], laser radar, ultra wide band radar (UWB) [12,13], and sensors on integrated circuits [14]. Innovative techniques for collision avoidance are sought that leverage advances in wireless communications, sensors (including optics and lasers), integrated circuits and digital signal processing algorithms. This technology would support AMRDEC concepts for small attack UAVs that may be used to seek and destroy terrain-masked targets as well as the AMRDEC technology base program Cooperative Unmanned Ground Attack Robots.

PHASE I: Provide a feasibility study of innovative collision avoidance techniques for small UAVs that address power and space constraints for on-board processing versus radar range. Provide functional block diagrams and discuss antenna characteristics, modulation formats, amplifiers, filters, processing algorithms, and system performance. Provide laboratory demonstrations to support the proof of concept.

PHASE II: Build a prototype system based on the Phase I design and conduct a field demonstration by integration on to a small UAV platform.

PHASE III: Transition to a military acquisition program for limited production and deployment. A Phase III commercial application would be for the Federal Aviation Administration (FAA) to require small UAVs (both military and civilian applications) to have these collision avoidance sensors on-board to operate in the NAS.
REFERENCES:
6) Beard, R. W.; McCain, T. W. Multiple UAV cooperative search under collision avoidance and limited range communication constraints. 2003 IEEE Conference on Decision and Control.
9) Sanderson, Craig. FPGA computing provides superior performance density for UAV applications. COTS Journal. 2003 June; http://www.cotsonline.com/

KEYWORDS: micro air vehicle, unmanned aerial vehicle, collision avoidance, see-and-avoid, obstacle detection, autonomous collision avoidance

A04-160 TITLE: Innovative Software Anti-Tamper Techniques

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Tactical Missiles

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

DESCRIPTION: All U.S. Army PEOs and PMs are now charged with executing Army and DoD AT policies in the design and implementation of their systems. Embedded software is at the core of modern weapon systems and is one of the most critical technologies to be protected. AT provides protection of U.S. technologies against exploitation via reverse engineering. Standard compiled code with no AT is easy to reverse engineer, so the intent of employed AT techniques will be to make that effort more difficult. AT techniques are being developed to combat the loss of the U.S. technological advantage, but further advances are necessary to provide useful and effective toolsets to U.S. Army PEOs and PMs. Current software AT techniques are only marginally effective.
This effort will focus on developing innovative new software AT techniques and technologies that provide more protection from compromise than current methods. Attention will be placed on integration into weapons platforms and their “real-time” processing requirements. The software AT technologies/techniques developed should provide a substantial layer of protection against reverse engineering. This capability will then allow the U.S. time to advance its own technology or otherwise mitigate any loss. As a result, the U.S. Army can continue to maintain a technological edge in support of its warfighters.

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

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

PHASE III DUAL USE APPLICATION: The contractor shall integrate selected AT techniques into embedded critical system software, for a military and/or civilian platform. This phase will demonstrate the products utility against industrial espionage, a problem that also impacts the U.S. Army and its mission. When complete, an analysis will be conducted to evaluate the ability of the technologies/techniques to protect against tampering in a real-world situation.

REFERENCES:

KEYWORDS: Anti-Tamper (AT), Real-time Software, Embedded Software, Reverse Engineering, Hacking, Exploit
Historically, gimbal and stabilization technology have been a large cost contributor to missile seekers. Improvements in this technology area will have to emphasize affordability.

Uncooled imaging IR technology has emerged in recent years with numerous applications in the commercial area. The development of field-worthy opto-mechanical assemblies coupled with commercially available detectors and advanced detector and gimbal technologies will provide a better understanding of the viability of uncooled infrared technology in Air Defense missile seeker applications at an affordable cost. New and innovative techniques are required to satisfy the affordability metric for uncooled imaging IR seekers.

PHASE I: Develop a design for low cost gimbal assembly/stabilization techniques applicable for use in Army air defense missile seekers, which could be used with emerging Uncooled IR Detector Technology. Investigate new and innovative gimbal technologies and/or stabilization techniques, which will be applicable for use in missile seekers. A study of present stabilization technology and of future Army requirements for Air defense missile, particularly with regards to Uncooled IR detector technology, is required.

PHASE II: Using the results of Phase I, develop and deliver to the US Army Aviation & Missile Research, Development and Engineering Center a low cost solution to the stabilization requirements. This assembly should be suitable for field and laboratory testing environment with Uncooled IR detectors as the primary application.

PHASE III: Development of this technology will be an asset, which covers a broad spectrum of use within the Army's mission objective. Army missile systems will make use of this technology such as Common Missile, NLOS-PAM Missile and other future Air Defense Systems. The private sector will have great interest in the technology. Uncooled IR detector technology is being used in the transportation industry, by law enforcement and fire departments, as well as surveillance and cartography endeavors.

REFERENCES:


A04-162 TITLE: Advanced Rendering Algorithms for Real-Time Physics-Based Sensor Scene Generation

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: NLOS-LS STO

OBJECTIVE: The objective of this topic is to research and develop physics-based software that can render near infrared, active laser sensor scenes on Commercial Off-The-Shelf (COTS) personal computer graphics cards much faster (> 10 times) than existing digital sensor simulations. A modular architecture employing these techniques is needed so inexpensive COTS PC hardware can be clustered to compute high bandwidth, active laser scenes. While these techniques will advance the state of the art in laser sensor technology development and application, they will also have broad application to lower cost, real-time, physics based rendering for commercial graphics markets.
DESCRIPTION: Active laser sensor concepts are being developed at a rate that is now exceeding the capability of legacy non-real-time simulations such as XPATCH and DELTAS to simulate sensor return signals in a timely fashion. While legacy near-infrared semi-active laser tracking systems are enjoying a resurgence in popularity, new LADAR sensors are being proposed and built for applications ranging from Future Combat System Unmanned Ground Vehicles (UGV), to missile defense, to aerial surveying. Modeling implementations of legacy scene simulations based on CPU based software has resulted in making sensor algorithm development and evaluation extremely time-consuming, costly and imprecise, particularly for LADAR. A new relatively novel approach is to use a COTS graphic accelerator card, with its optimized scene rendering hardware, to vastly decrease the computational time to calculate a complex near-IR scene. However, to take advantage of graphics card capabilities, a new scene generating architecture together with specialized rendering techniques require development. In addition, while databases of wave-band specific material properties exist, these databases have not yet been optimized for processing by COTS graphics processors. Computing scenes based on first-principle physics software designed to run on COTS graphic cards promises to substantially reduce the amount of time now spent computing signatures of each individual scene component using the typical PC CPU. These new rendering techniques and scene generation architecture would allow a simulation to operate at ever-higher rates and fidelities as COTS PC graphics card hardware evolves. Because of a video card’s hardware optimization, new software designed for it should accelerate the computation of laser energy reflected from tactical targets (highway, dirt, tanks, trucks, buildings), strategic targets (re-entry vehicles, plumes, debris), in a complex environment (atmospheric density, absorption, scattering, turbulence), while ultimately include the effects of complex clutter (dust, smoke, vegetation). New graphics card algorithms should allow flexible selection of sensor properties such as wave band, emitter source characteristics, and focal plane array (FPA) size. The scene generation technology should compute an in-band image for each frame of data collected by the sensor, up to 10,000 Hz. The ‘image’ data computed by these scene generation algorithms should be selectable (radiant intensity, reflected energy, range), depending on the sensor operating characteristics.

PHASE I: Develop algorithms implementing physics-based image generation using the hardware and programming interfaces available in COTS graphics hardware (PC graphics cards). Research scientific scene generation and sensor simulation methodology and develop a modular communication and control interface that can be scaled to compute high bandwidth scenes with clustered COTS computing hardware. Develop an approach to utilize existing and new model databases necessary for physics-based rendering.

PHASE II: Demonstrate a prototype system with rendering algorithms that compute real-time imagery in a wave band in the near-infrared spectrum. Compare results to non-real-time predictive scene data. Demonstrate the performance and modularity of these techniques and tools in a simulation environment of the vendor’s choosing.

PHASE III DUAL USE APPLICATIONS: Commercial applications of this topic are myriad, especially in the field of digital content creation (DCC) where game and movie vendors must render vast quantities of photo-realistic frames of imagery. Physics-based rendering technology in the visible spectrum will be highly marketable to the large market sector focused on manned flight simulators (cockpit trainers). Obviously, this topic is likely to produce testing tools for laser sensor technology for missiles, UAVs, manned aircraft, armor, and infantry. This technology would be useful for computing signature templates to be used by underwater remotely piloted vehicles (RPV) for detecting flaws in ship hulls, pipelines, and nuclear power plant cooling pipes. This technology is likely to produce commercial products marketable to aerial surveying, drug interdiction, and homeland defense by accelerating the development of burgeoning LADAR technology. This technology can provide a commercial system that provides low cost, real-time, synthetic range returns for virtual training of police and military forces using assault weapons with laser rangefinders and fused ammunition. This topic will produce methods for developing geometric models with embedded spectral and diffuse laser properties likely to result in a commercial tool that can be marketed to vendors of near infrared sensors that are used for police surveillance, geologic surveying, and homeland defense intelligence collection.

REFERENCES:
KEYWORDS: scene generator, seeker, hardware in the loop (HWIL), semi-active laser (SAL)

A04-163  TITLE: Energy Harvesting for Missile Health Monitoring

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Comanche

OBJECTIVE: Develop an innovative autonomous structural health monitoring system for missiles that has inherent capabilities for damage detection, self-diagnosis that uses energy harvesting for power supply.

DESCRIPTION: Sensor based Structural Health Monitoring systems are now being widely developed and used for many damage detection applications. Most systems however, require external inputs for proper functioning such as calibration, sensor diagnostics and power supply. These factors can limit the use of the systems and increase their operational costs. Therefore, there is a need to develop a completely autonomous structural health monitoring system that has all the capabilities to monitor the integrity of a structure without requiring any external electrical input or battery. Such a system would involve the development of integrated sensor arrays, self-calibration methods and energy harvesting using sensor arrays and have the capabilities to detect real-time damage in metal and composite structures through active and passive interrogation methods. The sensor arrays should have the ability to perform wide-area sensing to accurately pinpoint damage location and monitor its structural health condition. Wireless methods may be used for data transfer from the sensors using the inherent energy harvested by them.

PHASE I: Develop the framework required for prototyping of such an autonomous active structural health monitoring system. Conduct investigation into various sensors and methodologies that can be used for widespread area sensing, diagnostics and energy harvesting. Develop and assemble all the elements required for prototyping a system based on the requirements outlined above.

PHASE II: Develop a prototype system based on the framework constructed in Phase I. Interact with missile manufacturers to develop the system using battery free devices. Develop appropriate hardware and software for analysis, interpretation and transfer of diagnostic information using energy harvesting devices. Demonstrate and validate the developed wireless and batteryless system on a missile component.

PHASE III: Work with a missile contractor/manufacturer and US Army to validate system and integrate it with missile structures. The developed system will be directly beneficial for monitoring the integrity of missile structures. The system can also be used for the autonomous health monitoring for land, sea, and air vehicles, shipping container monitoring, shock event detection and reporting.

REFERENCES:
KEYWORDS: sensors, energy harvesting, structural failure, missile health monitoring, damage detection

A04-164 TITLE: Corrosion Sensors for Army Missile Systems and Aircraft Applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Common Missiles (PEO Tactical Missiles)

OBJECTIVE: To develop an effective monitoring sensor and/or sensor system for detection and/or measurement of corrosion on missile systems and aircraft in operation and storage. The development and application of an effective corrosion sensor would satisfy both military and civilian requirements for safety, reliability, and maintainability of aviation equipment as outlined in the General Accounting Office (GAO) reports on aging aircraft challenges.

DESCRIPTION: Corrosion is a significant detractor from military readiness, and represents a significant expense due to maintenance of equipment and replacement of parts. For example as reported in GAO Report No. 03-753, the Army estimated spending over $2 billion per year to repair corrosion damage on wheeled vehicles and spent around $4 billion in 1998 to repair corrosion damage on aviation assets. Preventive maintenance and periodic inspections are required to minimize the cost of corrosion and deterioration of equipment. However, most routine inspections are visual in nature and are limited to externally exposed areas. The challenge is that corrosion is not limited to external areas but also occurs in inaccessible areas where panels or covers are not removed except for repairs or comprehensive inspections. The development of a corrosion sensor and/or sensor systems to detect the presence of corrosion would be an effective way of ensuring deterioration control prior to corrosion initiated system failure. It would be an additional benefit if the proposed sensor or system was also able to determine the corrosion severity level if corrosion was detected. Using this information corrosion and deterioration due to environmental conditions could be minimized while also minimizing excess maintenance, inspection, or loss of the weapon system.

PHASE I: Conduct a feasibility study to determine the capabilities of current corrosion sensor or sensor system technologies to remotely monitor conditions conducive to corrosion. Develop a design failure mode and effects type of analysis to assess application critical areas or limitations of the sensor to various applications, i.e., types metals, type of coating systems (primer, primer and topcoat), environmental. Address other performance issues that may be unique to the U.S. Army operational environment. Through preliminary sensor sample testing, demonstrate the ability of the proposed sensors and/or sensor systems to predict the onset of corrosion.

PHASE II: Fabricate and demonstrate the corrosion sensor/sensor system feasibility on a specified missile system. Continue corrosion sensor sample testing to determine if a correlation exists between corrosion sensor readings and corrosion severity. Compare data from the missile system demonstration and the sample testing to verify the reliability of the sensor to detect: (1) the onset of corrosion and (2) severity of corrosion.

PHASE III: Demonstrate the application to multiple military or commercial systems, i.e., aircraft, ground vehicles, inaccessible areas of structure, etc. Demonstrate the commercial manufacturability of the sensor and/or sensor system. Hidden corrosion is endemic throughout the military and commercial fleets of aircraft and ground vehicles. Therefore, it is reasonable to expect a significant commercial market will exist for corrosion sensors and/or sensor systems to identify hidden corrosion or conditions which will lead to system failure resulting from hidden corrosion.

REFERENCES:
1) GAO-003-753 Defense Management: Opportunities to Reduce Corrosion Costs and Increase Readiness.
2) GAO/T-RCED-90-2 Meeting the Aging Aircraft Challenge: Status and Opportunities.
A04-165   TITLE: Integration of Multiple Models and MEMS Data into Computer Algorithms for Safe/Shelf Life Prediction of Rocket Motors

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Tactical Missiles

OBJECTIVE: Develop computer algorithms that integrate viscoelastic stress analysis solutions, material failure models, material aging models, statistical models, and data from MEMS sensors for evaluation of safe and service life of rocket motors. Develop mathematical models to describe viscoelastic material failure, response and aging.

DESCRIPTION: A fully integrated methodology for prediction of rocket motor service life, integrity, and reliability does not exist. Sensor suites and data loggers provide nearly continuous monitoring of environmental loads on fielded and stored rocket motors. Embedded sensors (in development) will provide further information about the response of energetic components to these now known loads. Yet verified/validated prognostics do not exist which relate ballistic and structural integrity of motors to measured loads. Prognostics currently include a number of models that describe material behavior and statistical analyses. However, in addition to lack of validation, a seamless algorithm that integrates failure, response, aging and statistical models does not exist. Current mathematical models for rocket motor component failure, response and aging must use factors derived empirically in order to approximate material behavior. More accurate models are needed in order to ascertain the reliability of rocket motors and provide a clearer path ahead for the Project Managers.

PHASE I: A graphical user interface (GUI) code suite will be developed, written in a Windows environment, that will integrate current models for service life and reliability analyses. Identify the key parameters that will be needed to develop a methodology for assimilation and analysis of volumetric environmental data from Remote Readiness Asset Prognostics/Diagnostics System (RRAPDS).

PHASE II: Expand GUI to link to expandable modules for structural analysis, aging, service life analysis, and reliability analysis. Develop advanced mathematical analysis models and add/expand modules to include new models. Develop Environmental Module to integrate RRAPDS data directly into the analysis process. Validate analysis algorithms using test analogs. (SBIR will be supplemented by in-house government testing.)

PHASE III DUAL USE APPLICATIONS: All DoD services and NASA deploy and store solid rocket motors. In addition, depots and some national labs have rocket motors in storage that are 30+ years old. The codes will be transferred to the DoD services and NASA via the Joint Army Navy NASA Air Force (JANNAF) organization for their use in analyzing their assets. Codes will be used to assist the depots and national labs in determining the structural integrity of motors in storage.

REFERENCES:

KEYWORDS: solid rocket motors, reliability, service life, propellant, physical properties, aging, structural integrity, modeling, failure, response, viscoelastic, MEMS, sensors, statistical analysis
ACQUISITION PROGRAM: PM Common Missile

OBJECTIVE: To investigate and develop a testbed to predict the performance of a specified IR seeker tracker or acquisition algorithm against targets within various backgrounds.

DESCRIPTION: There continues to be significant investment from DoD in imaging infrared technology for missile guidance. Simulations play an important role in IR seeker programs because of cost savings over testing and for performance prediction in a wide variety of environments and engagements. Though these detailed simulations exist, other performance models such as quick-look analytical models as well as the larger force-on-force models, do not adequately quantify the capability of specific tracker or autonomous acquisition algorithms that dictate the seeker’s performance. The lower level models only use simplistic metrics for environment and seeker parameters, and the force-on-force models use a random draw for probability of detection. A need exists to quantify performance of algorithm in a simplistic method based upon measures of a given scene without having to running the algorithm over each scenario. Performance for detection, acquisition, and tracker capabilities are specific to the algorithms, since every algorithm performs very differently with respect to backgrounds, false alarms, flight profiles, etc. This will allow a more robust and accurate analytic models to predict IR seeker performance and a more realistic capability of the IR weapon seekers in a force-on-force scenario based upon the specific algorithm being utilized for that weapon.

PHASE I: Conduct detailed analysis to develop the methodology for quantifying infrared tracker and acquisition algorithms based upon measures from background image sequences. Develop a detailed design of the testbed based upon the methodology selected. The testbed should accept either synthetic or real infrared image sequences and a given algorithm (track, detection, acquisition, etc). The testbed should produce an output of predicted performance based upon the scene or target information of the sequence provided. The image sequences planned for analysis should accommodate a wide variety of backgrounds, sensor resolutions and sensitivity levels to determine the various dependencies on overall performance. The design of the testbed should include the execution on a personal computer (PC) platform. A plan for verifying the testbed should be developed including data sources, equipment and analytical software, and proposed experimental and analytical techniques.

PHASE II: Develop the testbed designed in Phase I. Verify performance using furnished algorithms and actual performance for comparison to predicted performance. The results from this analysis should demonstrate proof of principle for predicting imaging infrared seeker performance unique to the algorithm under study.

PHASE III DUAL USE APPLICATIONS: This testbed will be a software product that has both military and commercial applications. For the military applications, Project Offices may use the testbed as a tool for algorithm trade-off studies or to implement within force-on-force simulations for more accurate evaluation of performance within various scenarios. Examples of other Government, but non-military, applications would be the Drug Enforcement Agency (DEA) and Police Forces that may use the testbed as a way of assessing their night sensors in detection of people under surveillance. The testbed allows assessment of any type of algorithm. Therefore, commercial uses such as machine vision and commercial remote sensing that require the evaluation of decision-making algorithms (non-man-in-the-loop) are directly applicable. Agriculture applications also include the analysis of satellite imagery for detecting land utilization of various crops. Medical applications for this tool include blood analysis from smear images in detection of blood cell components. The algorithm testbed is versatile to be utilized in most applications involving any type of algorithm or decision-making software.

REFERENCES:
KEYWORDS: Infrared, Infrared tracker, infrared algorithms, infrared performance algorithm, infrared seeker software, algorithm testbed

A04-167  TITLE: Low-Cost, Large-Area Conformal Detector Arrays

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Tactical Missile

OBJECTIVE: Develop fabrication techniques for low-cost, non-planar or conformal detector arrays.

DESCRIPTION: Applications exist in the military to detect reflected energy and pass target information on to weapon guidance systems. The designs currently used in semi-active laser (SAL) seekers are fairly large, relatively expensive, and usually depend on traditional optics designs, gimbaled platforms, and planar detector configurations. Next generation SAL applications are being designed for much smaller soldier-fired munitions, and will require significantly cheaper, more miniaturized detector and optical system designs than are currently available. One possible solution is an array of detectors that is conformal to the seeker optics. If multiples of an array can be manufactured in large areas and divided in a manner similar to printed circuit board panels, economies of scale can be realized. Flexible display technology is rapidly advancing, having demonstrated Thin Film Transistors on large-area flexible organic substrates. Excimer lasers are now being used to crystallize thin films of amorphous silicon. These and other technology developments, such as roll-to-roll processing and fluidic self-assembly techniques may aid in developing low-cost detectors on flexible and/or conformal substrates, which could provide part of the solution for very compact, low-cost SAL seeker assemblies for military applications.

PHASE I: Determine optimum detector material set(s) for spectral response in 1-2um (primary) and 9-11um (secondary) ranges. Determine suitable materials and low-temperature fabrication techniques for detectors on flexible substrates. Design a test vehicle substrate layout with interconnects for 2x2 and 4x4 arrays. To aid in demonstrating feasibility of material handling and detector fabrication methods, conduct multiple fabrication runs of the test vehicle first on a rigid substrate, then on a flexible organic substrate. Determine stresses placed on detectors that are on a flexible substrate that has been bent into a hemispherical shape. Examine multiple-up large-area batch design to decrease cost per array. Perform DC parametric probe tests on the fabricated detectors to determine functionality. Package the best detectors to perform optical testing to determine quality of devices. Investigate methods to increase performance, consistency, and yield of the developed fabrication processes. Determine feasibility of detector fabrication on pre-formed hemispherical substrates. Investigate optical system challenges evident in a conformal detector design.

PHASE II: Refine detector fabrication processes for higher yield (> 50%), large-area format. Increase detector responsivity to minimum 0.5A/W. Examine larger numbers of smaller pixels vs. increased routing/readout complexity. Design and fabricate breadboard version of readout electronics to demonstrate array performance. Package a mock-up of a miniature (< 2 inch diameter) SAL detector assembly with breadboard readout and signal amplification/processing electronics to submit for testing by the Army. Investigate potential for other configurations based on this technology, such as a detector substrate curved for optical efficiency, and 360-degree detector arrays. Develop a cost roadmap for flexible/conformal detector arrays.

PHASE III: Determine military and commercial markets beyond low-cost SAL seekers. Some potential commercial markets are for touch-screen flexible displays, 360-degree infrared sensors, and laser detection systems for homeland defense. The key is to develop high-yield, large area processes to bring about economies of scale. Detector performance requirements may be less stringent for commercial applications.

REFERENCES:

KEYWORDS: semi-active laser, flexible substrate, conformal detectors, amorphous silicon, laser crystallization, large-area patterning, flexible displays

A04-168  TITLE: Non-Intrusive Measurement Techniques for Scramjet Ground Test Environments

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Air Space Missile Defense

OBJECTIVE: To develop non-intrusive measurement techniques for the determination of flowfield properties, especially species, in the flowpath of a hydrogen fueled scramjet engine during ground tests.

DESCRIPTION: The U.S Army is pursing the development of hydrogen fueled scramjet engines to power high speed interceptor missiles in the flight Mach number range of 8 to 10. State-of-the-art computational fluid dynamics (CFD) models for multi-phase, chemically reacting flows will serve as the primary scramjet engine design and analysis tool to provide for end-to-end, inlet-to-nozzle, scramjet simulation. Complimentary end-to-end, inlet-to-nozzle, full scale scramjet engine testing will be conducted under duplicate flight conditions in the LENS shock tunnel facility to validate and verify the CFD model simulations. While much can be learned and inferred from high speed surface measurements for static pressure and heat flux in short duration (less than 50 millisecond) shock tunnel scramjet engine test runs, more direct non-intrusive measurement techniques are desirable to access fuel/air stream mixing and combustion. Indeed, considerable research has gone into the development of non-intrusive laser diagnostic techniques for the characterization of flowfields such as laser doppler velocimetry (LDV), coherent anti-stokes Raman spectroscopy (CARS), stimulated Raman spectroscopy (SRS), and laser induced florescence (LIF). Unfortunately, all such techniques for the determination of species concentration suffer from the inability to make high quality instantaneous measurements free from the influence of the measurement process and, as such, are unacceptable for use in this application. Additionally, any non-intrusive measurement technique for use in this particular application must be appropriate for the unique conditions associated with shock tube and scramjet operation. While the tunnel and flow conditions are very clean in terms of physical contaminants, heat, and vibration, the run times are short, data acquisition must be conducted remotely, and, line-of-sight access is limited. Furthermore, scramjet configurations of interest are not confined to planar two-dimensional designs. Clearly, new, innovative, and improved approaches are needed.

PHASE I: Phase I proposals must demonstrate: (1) a thorough understanding of the Topic area, (2) technical comprehension of scramjet flowpath physics and shock tube operation, and (3) previous experience in the development and use of non-intrusive flowfield measurement techniques. Technical approaches will be formulated in Phase I to address the key problem areas in the development of non-intrusive measurement techniques for scramjet ground test environments. If proven feasible, at least one innovative measurement technique for the determination of instantaneous species concentrations will be built, assembled, and bench tested in a laboratory environment to assess the potential for Phase II success.

PHASE II: The most promising technical approaches formulated in Phase I will be finalized and constructed as prototype non-intrusive measurement hardware for inclusion in the Government ground test of a full-scale hydrogen fueled scramjet in the LENS shock tube facility.

PHASE III DUAL USE APPLICATIONS: Non-intrusive flowfield measurement techniques have wide spread application both in the military and commercial arenas as wind tunnel analysis tools for the development of propulsion systems and the understanding of complex flow interactions. The development of such techniques to make high speed measurements of species concentrations in chemically reacting flows would have immediate application to the development of most propulsion hardware including
gas turbines, turbojets, and rocket engines.

REFERENCES:

KEYWORDS: Non-intrusive measurement technique, Scramjet, Shock tunnel, Combustion, Flowfield, Species concentration, Mixing

A04-169 TITLE: Innovative Hardware Anti-Tamper Techniques

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Tactical Missiles

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

DESCRIPTION: All U.S. Army PEOs and PMs are now charged with executing Army and DoD anti-tamper policies in the design and implementation of their systems to afford maximum protection of U.S. technologies, thus providing maximum protection against them being obtained and utilized and/or exploited by foreign adversaries. One area of vulnerability is in the electronics of the weapon system, where there are many critical technologies that can be compromised. Techniques are now emerging to begin to try to combat this loss of the U.S. technological advantage, but further advances are necessary to provide useful toolsets to the U.S. Army PEOs and PMs for employment in their systems. The effort will focus on identifying new hardware design and protection techniques and technologies that provide a greater level of protection than current manufacturing process, board/chip coating, obfuscation and self-destruct concepts currently under evaluation. It should be noted that the use of off-the-shelf components can seriously compromise an anti-tamper design due to the ready availability of open-source documentation about them. The effort should therefore focus on denying an adversary access to enough information to begin such a data search. The technologies/techniques developed should inhibit an adversary's hacking and/or reverse engineering effort to a point where it will require a more significant resource investment to compromise, thus allowing the U.S. time to advance its own technology or otherwise mitigate the loss. As a result, the U.S. Army can continue to maintain a technological edge in support of its warfighters.

PHASE I: The contractor will design and analyze the effectiveness of new and innovative anti-tamper techniques/technologies to protect weapon system critical components. The focus should be on denying an adversary access to details about radio frequency electronics such as solid-state transmitters, receivers, oscillators, and MMICs, or digital components such as analog-to-digital (A/D) converters, application specific integrated circuits (ASICs), and field programmable gate arrays (FPGAs).

PHASE II: The contractor will build prototypes of selected anti-tamper techniques/technologies and provide components for assessment of their effectiveness in preventing compromise of critical component functions and capabilities.

PHASE III DUAL USE APPLICATIONS: The contractor will integrate selected anti-tamper techniques into actual weapon system and/or commercial product critical components, as economic espionage is also a problem that impacts the U.S. Army and its mission. Upon completion, tests will be conducted to evaluate the technologies/techniques ability to protect against tampering.
REFERENCES:

KEYWORDS: Anti-Tamper, Reverse Engineer, Electronics, Self-Destruct, Material Coatings, Solid State Transmitter, Receiver, Oscillator, MMIC, A/D Converter, ASIC, FPGA

A04-170 TITLE: Consolidation of Nanograin Ceramics

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: JCM Project Office

OBJECTIVE: Fabricate optical-quality, nanograin size infrared-transparent windows with a grain size of 50 nanometers or less and mechanical strength at least twice as great as that of the conventional, large grain equivalent. The focus in this effort will be the consolidation to near net shape using nanograin powders developed under other programs.

DESCRIPTION: Nano and small grain optical ceramics offer the potential for improved mechanical strength over their larger grain counterparts. A tri-service effort to develop nanograin ceramics for missile domes and windows has culminated in several SBIR awards to develop unagglomerated, nanograin powders. Generating the powder, however, is only the first step in solving the problem. Once the nanograin powders are formed, they must be consolidated to transparency to form the required dome or window. Current efforts have focused on powder production but have not addressed the heat and pressure treatment required in the consolidation. Both heat and pressure tend to encourage rapid grain growth resulting in large grain ceramics. The objective of this effort is to start with small and nanograin powders developed in previous and current SBIRs and develop the techniques and procedures for forming the small or nanograin ceramic. It is believed that the tasks of generating the powders and consolidating to transparency are too large for a single SBIR. Powder formation is being addressed in other topics. This topic should focus on the densification of the powders. Proposals that attempt to devote significant effort to the synthesis of nanopowders will not be looked upon favorably. The offeror may need to synthesize powders for making ceramics, but the intent of this topic is not to devote research effort to new methods of making powders.

PHASE I: The objective of Phase I is to investigate techniques for making small or nanograin ceramic domes and windows. Phase I will concentrate on forming small, optically transparent coupons. The materials of choice include, but are not limited to, nanograin MgF2 and small grain Yttria. Multi-phase fluorides and multiphase oxides are additional candidate materials in which the multiple phases could serve to inhibit grain growth. Starting powders could be provided by existing SBIR efforts, might be synthesized by previously known routes by the offeror, or may be purchased by the offeror from other sources. Phase I efforts should consider handling of the small or nanograin powders or suspensions, formation of the green body compact, and densification of the ceramic to optical transparency. Limitation of the grain growth will be a significant focus of the effort. Ideal nanograin ceramics should have final grain sizes under 100 nanometers. Small grain ceramics, such as Yttria, may have grain sizes approaching 1 micron. A successful Phase I will deliver five 1" diameter optically transparent disk samples with grain size in accordance with the criteria above.

PHASE II: The objective of Phase II is to extend the techniques developed in Phase I to larger samples and to hemispherical shapes. The first step will be to increase the size of the optically transparent small or nanograin disks. Initially, the disk sizes should increase to 6" in diameter with the ultimate goal of a 6" diameter transparent hemispherical dome. Mechanical test coupons should be prepared and their strength should be measured as part of this effort. Details of testing will be agreed upon with the Government at the outset of Phase II. The final deliverables will also include two, optically transparent, 6" diameter hemispherical domes with nanograin or small grain structure.
PHASE III DUAL USE APPLICATIONS: Phase III will focus on developing the capability for high volume production of large domes or windows for tactical missiles with nanograin optical materials. In addition, applications in Navy and Air Force aircraft and missiles will be explored. These materials will have limited non-defense applications, however, those markets will be explored as well for high end window uses.

REFERENCES:

KEYWORDS: nanograin, infrared materials, dome, windows

A04-171  TITLE: High Strength Nanomaterials Fiber for Lightweight Composite Missile Cases

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Tactical Missiles

OBJECTIVE: Develop a high strength fiber for use in filament wound composites that utilizes the enhanced properties of nanomaterials. The fiber would be used for filament winding of rocket motor cases and other pressure vessels with the goal of reducing system weight.

DESCRIPTION: Recent advances in nanomaterials promise to improve fiber properties either by incorporating nanomaterials into existing fibers or creating fibers from nanomaterials. Carbon fibers used in state-of-the-art missile cases demonstrate a tensile strength of 924 KSI, a tensile modulus of 42.7 MSI with a density of 0.065 lbs/in³. Improvement in fiber strength would minimize the amount of material required to achieve a given performance and would therefore reduce the system weight. Beyond demonstrating fiber properties that exceed the properties of the state of the art, the fibers must be integrated into a composite and deliver a tensile strength of at least 800 KSI within the composite. The delivered strength can be demonstrated by tow strand testing and/or hydroburst of composite pressure vessels.

PHASE I: Develop an innovative process for creating a fiber that meets or exceeds the properties of state of the art carbon fibers. Integrate the fiber into a representative composite part and demonstrate compatibility and adhesion with commercially available resin.

PHASE II: Define a representative pressure vessel for Phase II demonstration. Fabricate composite pressure vessels utilizing candidate materials, demonstrate compatibility with current processing techniques, and conduct burst tests to evaluate delivered fiber strength. Fully document materials processing and application techniques.

PHASE III DUAL USE APPLICATIONS: A high strength fiber would be beneficial in many defense applications such as high velocity tactical missiles, attitude control systems, and launch tubes. This technology would provide significant weight savings in launch boosters, unmanned aerial vehicles, satellite systems and commercial applications such as high-speed transport aircraft. The commercialization of this technology will result in significant inert weight savings, providing high payoffs in terms of system efficiency and size.

REFERENCES:

KEYWORDS: Composite pressure vessels, carbon fiber, nanocomposite, nanofiber, filament winding.
TITLE: Affordable Efficiency Improvements for Small Turbine Based Flight Engines

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Tactical Missiles

OBJECTIVE: Design and develop improvements to small turbine based flight engines that will provide efficiency improvements over a selected baseline product while assuring that the improved product can meet military environment qualification requirements.

DESCRIPTION: Small turbine based flight engines are critical components of loitering systems for both missile and unmanned air vehicle applications. However, in order to meet stringent mission requirements as well as Army affordability needs, innovative research is required to infuse the cost benefits of commercial products into higher performance, environmentally robust defense products. The current effort would use an existing small turbine engine product to provide performance and cost baselines. One or more improvements (design based, material based, manufacturing process based, or some combination) would be selected and their associated performance improvements and cost impacts demonstrated. The improved product would be demonstrated as being capable of meeting a selected lethality focused mission requirement (e.g. loitering and/or armed UAV system applications), to include critical aspects of environmental qualification.

PHASE I: Establish baselines and demonstrate the feasibility of proposed improvements to provide increased efficiency of small turbine based flight engines when used in realistic military environments.

PHASE II: Utilizing the results of Phase I, select a set of improvements and develop, produce and demonstrate a prototype system. Conduct performance and environmental testing to prove the feasibility of meeting one or more lethality based missions.

PHASE III: Focus on the commercialization of the technology based improvements through integration into engine manufacturer’s design/production system for use in future engine development programs. Also pursue application of improvements to existing military and commercial small turbine engines.

REFERENCES:
1) C. Rodgers, ITC; Air Turboramjet or Turbojet for Small Tactical Missile Propulsion; AAIA 96-0378, 1996.
2) S. Burguburu, A. Pape; Improved Aerodynamic Design of Turbomachinery Bladings by Numerical Optimization; Aerospace Science and Technology 7 (2003); pp: 277-287.

KEYWORDS: Small Gas Turbine Engines, Manufacturing, and Affordability

TITLE: Alternate Scramjet Fuel Modeling and Evaluation

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Air Space Missile Defense

OBJECTIVE: To develop the methodology for the analytical evaluation of alternate scramjet fuels.

DESCRIPTION: Hydrogen remains as the only fuel of choice for high velocity scramjets at flight Mach numbers greater than about 8 because of the necessity for rapid mixing and fast chemical kinetics. Unfortunately, hydrogen as a fuel leads to significant system penalties because of the very low density and consequent large volume for gas phase storage or, alternatively, the low hydrogen mass fraction in liquid phase storage. One innovative and as yet unexplored technique to remedy this inherent short-coming in hydrogen as a fuel is to augment the gaseous hydrogen with traditional high energy particles such as aluminium or even metal hydrides. These particles would of
necessity have to be very small, perhaps even nanoscale, for complete combustion within the scramjet flowpath. However, the design, development, and validation process for mixing and combustion of augmented hydrogen fuels has a very low probability of success without a comprehensive first principles based physical and thermochemical model for these supersonic, multi-phase, chemically reacting flows. A first principles design tool, as such, would be used first simply to lend credence to the concept of augmented hydrogen fuels for scramjet applications. Then the model would be used to rank candidate fuels and also to perform trade studies for particle injection schemes over a range of flight trajectories and operating conditions.

State-of-the-art computational fluid dynamics models for multi-phase, chemically reacting flows would serve as the foundation to build such a design tool for alternative scramjet fuel modeling and evaluation; however, significant advances must be achieved. For example, the computational fluid dynamics model must provide for end-to-end, inlet-to-nozzle, scramjet simulation. Furthermore, the model must account for the competing reactions for oxygen-heterogeneous particulate surface chemistry and homogeneous gas phase hydrogen combustion. Particulate surface chemistry models with suitable ignition, phase change, and heat transfer for representative particle geometries and size distributions will be required. Clearly, new, innovative, and improved approaches are needed.

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

Technical approaches will be formulated in Phase I to address each of the key problem areas for inclusion into computational fluid dynamic models. If proven feasible, at least one innovative, meaningful demonstration of competing homogeneous and heterogeneous reactions for a particle augmented hydrogen fuel in a supersonic air stream will be proposed and a flowfield solution produced with the computational model during Phase I to assess the potential for Phase II success.

PHASE II: The additional model improvements formulated in Phase I will be incorporated as prototype computational fluid dynamics submodels for inclusion into an existing Government or commercially available computational fluid dynamics model. This advanced computational fluid dynamics model will be run blind for a hypersonic scramjet test case for which detailed flowfield data will be available to demonstrate the advanced capabilities for analyzing and modeling particle augmented hydrogen combustion interactions.

PHASE III DUAL USE APPLICATIONS: For military applications, this technology is directly applicable to all air breathing missile propulsion systems. For commercial applications, this technology is directly applicable to advanced propulsion techniques for commercial applications such as high speed supersonic transports and to orbital launch systems.

REFERENCES:

KEYWORDS: Computational fluid dynamics, Two-phase, gas-particle flow, Finite-rate chemistry, Combustion, Scramjet, Computational fluid dynamics, Propulsion, Numerical methods
OBJECTIVE: The objective of this topic is to develop an innovative method to provide an integrated thrust management control system that controls both the magnitude and direction of thrust of a solid propellant rocket motor.

DESCRIPTION: Future Army tactical missiles are requiring advances in propulsion to provide extended range and mission flexibility for multiple targets. Traditional solid propulsion systems provide a fixed thrust profile and have separate thrust vector control (TVC) systems that are integrated into the missile system. To advance state-of-the-art in propulsion control, it is desired to fully integrate TVC into a controllable solid propulsion system, providing both thrust magnitude control and vectoring control. Unique methods to control thrust, to include variable area nozzles, should be considered as well as unique methods to provide coupled TVC for a truly integrated thrust solution. Design considerations should maximize thrust turndown and thrust vectoring angle, and should minimize performance losses, volume and weight, actuation requirements, and power requirements. The design should provide the ability to operate the propulsion system in a pulse type mode, with a low pressure operating capability. Unique designs that eliminate or greatly reduce actuation and power requirements should be considered. Designs that reduce volume and weight of the thrust vectoring component over that of conventional TVC systems such as jet vane systems should be explored. Consideration should be given to increasing tactical missile performance in terms of maximum range, missile control authority, and mission flexibility (multiple target capability).

PHASE I: Phase I shall encompass the design and analysis of propulsion system concepts that fully integrate thrust magnitude control with TVC. Propulsion concepts should be evaluated against missile performance capability, thrust turndown capability, thrust vectoring capability, actuation and control requirements, volume and weight of the integrated system, and projected production cost. Missile performance benefits such as maximum range and mission flexibility should be evaluated in the analyses. A preliminary design shall be completed during Phase I and performance predictions provided, including propulsion system performance and (conceptual) missile performance. A preliminary design shall be recommended for the Phase II effort.

PHASE II: Phase II shall encompass the final design, analyses, fabrication, and testing of prototype hardware. Bench tests should be conducted on thrust control components. Cold gas testing may be used in bench tests for validation of thrust control capabilities. Consideration should be given to multiple hot gas static tests to validate the components. To this end, existing heavywall rocket motor hardware may be used for any bench tests or prototype tests. Final deliveries to the Government at the end of any Phase II effort shall include all hardware (rocket motor, thrust management system, actuators and controllers if necessary, etc.) and software necessary to conduct an independent test at Government facilities. The culmination of Phase II shall be a prototype demonstration of integrated thrust control.

PHASE III DUAL USE APPLICATIONS: A potential Phase III military application of this technology is the Non-Line-of-Sight Launch System (NLOS-LS), which requires an advanced propulsion system to meet system requirements. Other potential applications include the Joint Common Missile, the PAC-3 Missile System Enhancement, and MEADS. Potential commercial applications include space propulsion and satellite propulsion, the aircraft industry, and the chemical industry. This technology would benefit commercial satellite propulsion systems by providing remotely actuated and controlled thrust systems, coupled with vectoring for more accurate positioning of satellites in orbit. The aircraft industry, where use is made of thrust diverters for take-off and landing, as well as actuation and control systems used for wing and tail control, could benefit from this technology. Another potential commercial application would be the chemical industry, where the need for controlling both the amount and direction of the flow of hot gases produced in reactors or columns is necessary for the chemical processes to occur. Any Phase III effort shall attempt to incorporate the following. A detailed performance analysis shall be conducted on the integrated system, to include ballistic analyses, computational fluid dynamics analyses, structural analyses, and thermal analyses. It is desired that a conceptual missile performance analysis be conducted to quantify performance benefits of the integrated system.

REFERENCES:
A04-175  TITLE: Development of a Highly Integrated Multifunctional Optical Sensor for Monitoring Weapons Health and Battlefield Environments

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Comanche

OBJECTIVE: The objective of this effort is to develop a highly integrated, multifunctional optical sensor for in situ monitoring of weapons health and microbial/chemical environments. The goal is to compare the performance of highly integrated optical sensors with conventional individual electronic and mechanical sensors and improve the performance through the use of advanced optical sensing technologies. The use of this highly integrated optical sensor should result in a sensor with higher sensing capability (such as sensing multiple parameters simultaneously) and sensitivity, lower cost, lighter weight, higher robustness, and smaller size.

DESCRIPTION: Knowledge and control of the entire microbial and chemical environment are critical for the health of battlefield soldiers, as well as weapon systems. Monitoring of the microbial environment may include the air, water, food, weapons, military vehicles, and life support subsystems. Monitoring of the chemical environment may include detection of both organic and inorganic contaminants that could result from gradual buildup of, or accidental contamination with harmful chemicals. However, traditional electronic and/or mechanical sensors are cumbersome and sensitive to harsh battlefield environment such as external electromagnetic wave interference and vibration. On the other hand, optical sensors can be immune from electromagnetic wave interference and vibration. In particular, with the rapid advancement of optics technology in recent years, largely due to the requirements from the telecom industry, all key components required for optical sensors such as light sources, detectors, sensing fibers and waveguides, are available with lower cost and higher performance. The time is right to develop a highly integrated multifunctional optical sensors by taking advantage of the state-of-the-art optics technologies such as advanced integrated optics circuits, photonic nanostructures. This highly integrated portable optical sensor will become an indispensable tool for future battlefield soldiers.

PHASE I: Conduct a feasibility study on an innovative highly integrated multifunctional optical sensor for in situ environment monitoring. The study should include the detailed sensor design, performance analysis (such as sensitivity, agents to be detected, robustness), and cost evaluation.

PHASE II: Develop an optical sensor prototype based on the design in Phase I. The performance of the sensor will be experimentally tested. Investigate the application of this optical sensor to the real world.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can also be used beyond military applications such as combating terrorists’ chemical/biological attack, environmental protection, as well as weapons health monitoring.

REFERENCES:
2) Valli, L., et al., JACS, 2003, 125, 9055.

KEYWORDS: Optical sensors, fiber optics, integrated optics, photonic nanostructures, integrated sensor, environmental monitoring.

A04-176  TITLE: Strategically Tuned Absolutely Resilient Structures

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Comanche
OBJECTIVE: The development of a highly resilient, damage tolerant, fatigue resistant innovative structure which is
cost effective, easily serviceable, safe, reliable, and efficient.

DESCRIPTION: Strategically Tuned Absolutely Resilient Structures (STARS) are composites, fabricated by
placing a low modulus, lightweight inorganic matrix over multiple layers of a relatively stiff reinforcement. These
remarkable concoctions are designed so that they can be highly stressed and deformed to store large amounts of
elastic strain energy. When the structural response is modified as the service loads are decreased, the energy is
released in a controlled fashion to do useful work.

STARS are designed based on the strength, stiffness, and the position of the component materials in the composite
section. Their ability to store and release energy depends upon a complex interaction between the shape, modal
response, and the forcing function initiated to the structure. Advanced systems will function as smart structures
that include sensing elements to monitor structural integrity and control elements to adjust the dynamic response.

Preliminary research shows that inorganic STARS offer structural engineers more design flexibility than traditional
advanced aerospace composites fabricated from materials such as graphite or Kevlar epoxy. Future plans call for
developing this technology by building mechanical energy storage devices that can be incorporated into advanced
propulsion and tactical weapons systems. Since the materials used to build STARS are inert and less sensitive to
corrosion, nuclear bombardment, and electromagnetic radiation than their traditional counterparts, they should
function better in the hostile environments found in space and on the battlefield. The work combines a novel design
concept with a proven sensor technology and will result in cost effective, easily serviceable, safe, reliable, and
efficient structures. Once they have been installed, the only instrumentation needed to monitor the structures is a
suitably equipped, portable, personal computer.

The study will involve the development of the theory required to quantify the structural performance of the
composite sections; production of a software package to facilitate structural analysis; mixture design to produce a
lightweight, low modulus matrix having sufficient strength to meet the design requirements; carbon fiber reinforced
polymer tendon design to produce strong and stiff elements compatible with sensor integration; structural testing of
the matrix and the tendons; fabrication of composite structures having embedded sensors; and, structural testing of
the composite sections and verification of the overall approach.

PHASE I: Explore the concept for a highly resilient, damage tolerant, and fatigue resistant structure. Provide a
feasibility study that addresses cost, service methods, safety, reliability and efficiency. Demonstrate the technology
using a simple structure (a composite structural system) fabricated from realistic structural materials. Perform a
manufacturability analysis and cost benefit analysis of deployment showing that the structure can be produced in
reasonable quantities and at reasonable cost/yields, based on quantifiable benefits, by employing techniques suitable
for scale up. Provide a report on scalability, performance characteristics, anticipated yield, and volume costs.

PHASE II: Based on the results/findings of phase I, implement the technology, fabricate, and test a prototype on a
complex structure system with carbon fiber reinforced polymer tendon and matrix with integrated sensors.
Demonstrate the system’s viability and superiority under a wide variety of conditions typical of both normal and
extreme operating conditions. Develop structural analysis software to analyze this new class of composites.
Demonstrate scaleable manufacturing technology during production of the articles.

PHASE III: Verification of overall approach. Provide a final design for an innovative composite structure that will
withstand potentially catastrophic conditions. The proposed technology under this effort would advance the state-of
the-art in structural performance, safety, life extension, preventative and other maintenance, homeland security
sensing, medical applications (e.g., automatic body function monitoring and multiple pharmaceutical dispensing),
enhanced turbine blade performance for wind energy production in low speed/turbulent conditions, earthquake
resistant buildings, deformable hydrofoils for high performance submersibles, bionic structures for sports (e.g. race
cars, etc.) and in a spectrum of other areas, for both the government and private sectors. Demonstrate commercial
scalability of the manufacturing process and the implementation of the software-based design tools for the
commercial development and deployment of advanced structures. Commercialize the technology for both military
and civilian applications.
REFERENCES:

KEYWORDS: smart structures, intelligent materials, compliance composites, nanocomposites, sensors

A04-177 TITLE: Field Deployable Diagnostic Test for Active Cutaneous Leishmania and a Test for Latent Infection

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE:
1) Develop, construct or adapt a lightweight compact field deployable diagnostic kit for detecting cutaneous disease caused by Leishmania parasites.

2) Develop, construct or adapt a diagnostic kit for detecting latent infection caused by Leishmania parasites.

DESCRIPTION: The Military Needs an Easy-to-Use, small logistic footprint, Diagnostic Device. The military needs an FDA approved field diagnostic that can detect Leishmaniasis in associated skin lesions (from skin biopsy or skin scraping, or other convenient sample). This diagnostic system must have outstanding sensitivity and high specificity.

The military also needs an FDA approved diagnostics test that can detect latent infection (an "in vitro" skin test) using whole blood. This diagnostic system must have outstanding sensitivity and high specificity.

The optimal goals for both would be > 95% specificity and > 97% sensitivity. Minimum goals would be >90% specificity and sensitivity, though FDA will set goal of final product. For the point of care device, it is desirable that it should be small (size of credit card), rapid (< 1 hour), stable in military operational environments, not requiring refrigeration, nor specialized training to perform the test.

The current gold standard is microscopic identification of the parasite in infected tissues whose sensitivity is limited by presence of parasite in tissue examined.

Currently non-FDA approved skin test antigen(s) are available to civilian medical caregivers in developing countries for diagnosis of latent leishmania infection. However, an FDA approved product, manufactured under cGMP from a clean seed isolate might be more favored in more developed countries, such as India and Brazil, around the world, if cost is reasonable.
PHASE I:
The awardee must draw upon the current knowledge and understanding of the disease to research and identify viable options for developing a diagnostic device for detection of Leishmania in the human body. Phase I will evaluate and adapt current and cutting edge diagnostic technology for detecting Leishmania as a field diagnostic device. Goal is for a CLIA waived, FDA approved or cleared device.

The goal in Phase I is to demonstrate that the selected diagnostic platform can be adapted for the detection of leishmania using test antigens. Awardees should discuss the availability of potential test antigens/samples with the Director of Research, Walter Reed Army Institute of Research.

PHASE II: Draw upon successful research in Phase I to develop a prototype diagnostic test kit to determine Leishmania infection. The test will be reliable, easy to use, light-weight, highly sensitive and field deployable for diagnosis of active disease. The test may be lab based for detecting latent infection.

PHASE III DUAL USE APPLICATIONS: Based on successful development of a prototype diagnostic test, perform required field trials demonstrating accuracy and effectiveness to the satisfaction of the FDA. Leishmania is endemic in many regions of the world. A simple, inexpensive diagnostic for cutaneous and/or visceral leishmania could be used by the civilian medical community in regions of endemic disease and in travelers to these regions. These technologies may also be applicable to other diseases of interest to the military or civilian medical communities.

REFERENCES:

KEYWORDS: leishmania, leishmaniasis, cutaneous lesion, sand fly, infectious disease, force protection, biotechnology, antigen detection, diagnostic, diagnosis

A04-178 TITLE: Development of an Intracavitary Hemostatic Agent for Use in Noncompressible Hemorrhage

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: To develop an intracavitary hemostatic agent for testing in combat-relevant animal models of severe noncompressible hemorrhage. If successful, this hemostatic agent would proceed to clinical trials for treatment of severe intracavitary hemorrhage.
DESCRIPTION: Noncompressible hemorrhage (i.e., hemorrhage not accessible to direct pressure) continues to be a primary cause of death in both military and civilian trauma (1-2). Currently, there is no treatment short of surgery for severe abdominal bleeding resulting from either blunt or penetrating injury. One concept that has been suggested is the development of a hemostatic agent that can be placed directly into the abdominal cavity (through a trocar or similar device) that would promote coagulation and provide internal tamponade (3). Development of an agent that requires direct interaction with the injured tissue to provide hemostasis is problematic because of the difficulty that this agent might have in reaching the injured tissue through pooled or flowing blood. If an agent that requires direct interaction with the injured tissue is proposed, the development of a delivery system that will overcome this obstacle must also be proposed. The current effort is to develop and test a prototype intracavitary hemostatic agent that will be efficacious in militarily-relevant animal models of severe intracavitary hemorrhage. Additionally, use of this agent must be safe (i.e., not produce abdominal compartment syndrome) and must meet requirements for battlefield use (i.e., be low-weight, low-volume, and low-cube; require minimal or no mixing of components; able to be stored/used at environmental temperature) by medical personnel at the training level of combat medics.

PHASE I: Develop a putative hemostatic agent that is likely to promote coagulation and provide hemostasis without manual compression under conditions of severe intracavitary hemorrhage. Successful completion of Phase I will result in development of an agent that could reasonably proceed to animal testing. Preliminary “proof-of-concept” experimentation in ex vivo models (e.g., testing for adhesiveness to ex vivo tissue) is desired for demonstration of efficacy.

PHASE II: Perform preclinical animal testing in animal models of severe trauma. Requirements for successful completion of this phase include successful use in a well-controlled animal study using a standard model of severe venous/parenchymal injury where the agent is introduced into a closed abdomen. Success therefore requires effective delivery to the injured tissue (if this is required for hemostasis) and/or achievement of hemostasis. The study should be performed with sufficient group sizes to demonstrate statistical significance in terms of blood loss and survivability. Successful completion of Phase II will result in a hemostatic agent/device that is ready for entry into clinical studies.

PHASE III DUAL USE APPLICATIONS: In this phase, the prototype modifications should be completed and human clinical samples developed. Human clinical studies should be designed and conducted to provide safety and effectiveness data. Because of the high incidence of life-threatening hemorrhage associated with both military and civilian trauma, an intracavitary hemostatic agent/device would have wide applicability in trauma centers throughout the world. Such an agent will decrease the significant mortality secondary to uncontrolled hemorrhage and has the potential to decrease adverse sequelae subsequent to hemorrhage.

REFERENCES:

KEYWORDS: intracavitary hemostasis, noncompressible hemorrhage

A04-179 TITLE: Human Biomonitoring Device for Military-Relevant Chemical Exposures

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC
OBJECTIVE: Develop a biomonitoring device that incorporates microelectromechanical systems, microfluidics, or similar technologies to measure biomarkers of exposure to toxic industrial chemicals and materials in the body fluids of military personnel. The chemicals of greatest concern include: common heavy metals (lead, uranium, cadmium), industrial compounds (benzene, toluene, ethyl benzene, xylenes), and agricultural pesticides (pyrethrins, organophosphates). The desired size of the device would be comparable to a Personal Digital Assistant (PDA), but it should not exceed the size of a laptop computer.

DESCRIPTION: The biomonitoring device would collect body fluids in a noninvasive or minimally invasive manner (e.g., urine or blood serum) and provide quantitative results for specific biomarkers within four hours. Ideally, the device will require only microliters of body fluids and will accurately quantify exposures to select heavy metals and industrial/agricultural chemicals. The device may incorporate "plug-in" chips or cards for different chemicals or classes of chemicals. The logistical burdens of the device will be minimal compared to conventional laboratory analyses of biomarkers: the device will be field portable and not exceed the size of a laptop computer.

PHASE I: The contractor will provide a proof-of-concept demonstration using relatively mature technologies such as microelectromechanical systems, microfluidic chips, and lab-on-a-chip platforms. Sensitivity and specificity must be comparable to conventional methods of biomarker analysis in published guidelines and scientific/medical literature (see references). Conceptual designs will be also be provided and will include a method for sampling biological fluids from humans. This phase shall not involve human studies.

PHASE II: The contractor will conduct the necessary research to develop a device using the conceptual design from Phase I. This includes developing individual components such as biochips that can separate biomolecules and provide quantitative data on specific biomarkers in biological fluids. Experimental data will be collected to determine the sensitivity and specificity of the components and to evaluate its feasibility for human biomonitoring applications. The criteria for sensitivity and specificity shall be based upon conventional methods in published guidelines and scientific/medical literature. The individual components will then be incorporated into a prototype device and must demonstrate capability in the laboratory to measure specific biomarkers of exposure for at least three different industrial and agricultural chemicals. At the conclusion of Phase II, the contractor shall provide two prototype devices that can be used in human cross-sectional studies, which will be conducted by military medical personnel.

PHASE III DUAL USE APPLICATIONS: The biomonitoring devices and/or supplies will be considered for use in operational risk management decisions and military deployment health surveillance. Biomonitoring devices also have broad civilian applications in homeland security, disaster response, and occupational health. For example, chemical spills and accidents often require biomonitoring of first responders and the population at risk of exposure. Similarly, occupational exposures to industrial chemicals can be better assessed by biomonitoring in the workplace. These devices can also be modified to include new or novel biomarkers for additional chemicals of concern.

REFERENCES:
KEYWORDS: biomonitoring, biomarkers

A04-180  TITLE: Developing a Catalytic Bioscavenger for Organophosphorus Nerve Agents

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: The Army has a need for a prophylactic bioscavenger that can detoxify organophosphorus nerve agents (OPs) at a rate sufficient to protect against exposure to 5 lethal doses. Furthermore, this scavenger should be non-toxic, produce no adverse side effects, have no adverse effect on performance, be easy to administer, and have a long biological half-life. Currently, the human enzyme butyrylcholinesterase (Hu-BuChE) is the lead compound being developed as an anti-OP bioscavenger. This molecule, while effective as a bioscavenger, is intrinsically limited in that it binds stoichiometrically (on a one-to-one basis) to OPs, requiring a substantial weight of enzyme to detoxify a lethal dose of an OP. The objective here is to use random mutagenesis, directed evolution, gene shuffling, or other techniques as appropriate to modify the gene encoding either Hu-BuChE or some other human plasma protein to create an enzyme that catalyzes the hydrolysis of OP nerve agents at a rate sufficient to act as an OP bioscavenger in vivo. This modified protein will then be produced in sufficient quantities to be evaluated for safety and anti-OP efficacy in relevant animal models.

DESCRIPTION: The development of biological scavengers as a next generation mode of medical protection against chemical warfare threats was the goal of a recently completed Army Defense Technology Objective (CB28 – Chemical Agent Prophylaxes II). The current vision for scavengers is that they will be proteins or other moieties that can be administered through intramuscular, transdermal, oral, or intravenous routes, and that they will circulate in the blood for relatively long periods of time causing no physiological or behavioral effects (1,2). Upon exposure to OPs, the scavenger molecules will bind and sequester or enzymatically inactivate the toxins at a rate sufficient to protect acetylcholinesterase (AChE), the toxic target of OPs, from inhibition. Such an approach is appealing because it would require no additional medical countermeasures either before or after OP exposure, and would produce no adverse effects because the OPs would be eliminated before they inflict damage.

Hu-BuChE has been identified as an effective bioscavenger of OPs (3-9), and is currently being transitioned into advanced development by the United States Army Medical Research Institute of Chemical Defense (USAMRICD). Hu-BuChE has several features that make it a useful bioscavenger candidate. It is a naturally occurring human plasma enzyme with a relatively long in vivo half-life. Because it is an endogenous self-protein, administration of additional Hu-BuChE is unlikely to induce an immune response that could lead to rapid clearance of the scavenger or even anaphylactic or autoimmune reactions. Finally, Hu-BuChE reacts with all known OPs, and thus would supply broad-spectrum protection against a variety of both known and non-traditional nerve agents (3-9).

The utility of Hu-BuChE as a bioscavenger is limited, however, by the nature of its interaction with OPs. Hu-BuChE, like AChE, binds most OPs in an essentially irreversible way, at a ratio of one molecule of OP bound to one molecule of Hu-BuChE (i.e. stoichiometric binding). The difficulty lies in the fact that OPs generally have masses between 160 to 300 Daltons, while a monomer of Hu-BuChE has a mass of ~90,000 Daltons (10). Therefore, a substantial weight of enzyme (roughly 200 mg for a 70 Kg person) is estimated to be necessary to protect from even two lethal doses of an OP. Additionally, because Hu-BuChE binds in an essentially irreversible fashion, a pretreatment with Hu-BuChE will only protect against an equimolar exposure to OP. To obtain additional protection against either higher doses or subsequent OP exposures, more Hu-BuChE would need to be administered.

One way to avoid these problems would be to use an enzyme that detoxifies OPs through hydrolysis rather than stoichiometric binding. A single mole of a catalytic bioscavenger with sufficiently rapid activity would be able to detoxify many moles of an OP in a short period of time, reducing the amount of scavenger required to afford protection. Additionally, the protection supplied by a catalytic scavenger would not be limited to a single OP exposure. Many enzymes with catalytic anti-OP activity have been identified, including the squid
diisopropylphosphorofluoridate hydrolyzing enzyme DFPase (11), organophosphorus acid anhydrolase (OPAA) from Alteromonas (12), and the phosphotriesterase (PTE) from Pseudomonas diminuta (13). However, most of these enzymes are of non-human origin, making them unsuitable for use as bioscavengers in human. Two notable exceptions exist; the first is the human paraoxonase 1 (Pon-1) enzyme, which has been shown to have low but detectable anti-OP hydrolyzing activity (14, 15). The second is a laboratory-generated mutant of Hu-BuChE in which the glycine at amino acid residue 117 was replaced by a histidine (G117H) (16, 17). Unfortunately, the catalytic rates of these two enzymes are too low to afford protection substantially above that of a stoichiometric scavenger (see discussion in 18). Nonetheless, together these two examples suggest that with a minimal number of alterations introduced through random mutagenesis, gene shuffling, directed evolution, and error-prone DNA replication, it might be possible to create an essentially human enzyme with a suitable level of anti-OP catalytic activity. The generation, characterization, and functional testing of such a catalytic bioscavenger are the goals of this project. If successful, the resulting catalytic bioscavenger will be of great use in protecting soldiers from OP toxicity, will reduce reliance on MOPP gear, and may help to deter the potential proliferation of OP agents in the future.

PHASE I: The goal of phase I is to generate an enzyme with broad-spectrum catalytic anti-OP activity that remains as similar as possible in primary amino acid sequence to an endogenous human protein. Candidate bioscavenger genes to be mutated could include (but are not limited to) human BuChE, Pon-1, AChE, carboxylesterase or others. In conjunction with any mutational system will be a method to produce sufficient quantities of each mutant protein to evaluate anti-OP catalytic activity. Because OP nerve agents are surety materiels and therefore unavailable to the general public, the use of appropriate OP simulants (e.g. pesticides) would be acceptable. Alternately, the authors at USAMRICD offer to collaborate with respondents to conduct screening of mutants for anti-OP activity with surety materiels, if appropriate. We envision the identification of one to three mutated enzymes with catalytic efficiency (as measured by kcat/Km (catalytic rate / Michaelis-Menten affinity constant) for one or more OP substrates or simulants) at least 10-fold higher than wild-type human Pon-1.

PHASE II: Mutant molecules with enhanced anti-OP catalytic activity will be produced and purified in sufficient quantities to be tested for in vivo for pharmacokinetics and efficacy against OPs. One or more appropriate small animal models (e.g. mice or guinea pigs) could be used for these in vivo studies. As in Phase I, the use of pesticides or other appropriate OP simulants to determine the in vivo efficacy of mutant enzymes would be acceptable. Alternately, the authors at USAMRICD offer to collaborate with respondents to use bona fide nerve agents in in vivo efficacy tests. Successful mutant enzyme(s) will be transitioned into large-scale protein production (such as tissue culture/fermentation or large animal transgenic expression), and development of a GMP-standard protein purification method will be initiated.

PHASE III DUAL USE APPLICATIONS: A mutant version of an endogenous human protein that displays substantial anti-OP catalytic activity would be of use as a prophylactic treatment not only to the US military (Army and other branches), but also for a variety of civilian applications. For example, civilian first responders and hazmat team members reacting to accidental or intentional OP releases, agricultural workers exposed to OP pesticides, and (depending on the specificity of the bioscavenger enzyme) patients suffering from either cocaine overdose or succinylocholine-induced apnea, are all potential users of catalytic anti-OP bioscavengers.

REFERENCES:

KEYWORDS: Organophosphorus Nerve Agents, Bioscavengers, Mutagenesis, Gene Shuffling, Directed Evolution

A04-181	TITLE: Nonviral Gene Therapy

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Develop a gene therapy using “Sleeping Beauty DNA Transposon system” for neoplastic diseases.

DESCRIPTION: The intent of this topic is to develop gene therapy for neoplastic diseases using non-viral vector system e.g. “Sleeping Beauty Transposon System” to replace defective genes with functional ones. Gene therapy is a promising therapeutic modality for neoplastic diseases. However, a key problem in gene therapy is the lack of a vector system that fulfills all the requirements for safety and efficacy. A number of gene delivery systems, including virally based vectors as well as non-viral methods, are presently being explored as potential DNA delivery vehicles for gene- and immunotherapy. Viral vectors based on retrovirus, lentivirus and adeno-associated virus are the most promising vectors at this time. However, immunological barriers are a problem for all viral vectors, but particularly for adenoiral vectors (Nikunj et al 2000 & Kootstra et al., 2003). In the case of neoplastic diseases, gene therapy currently typically uses viral vectors to replace defective genes with functional ones. In addition to eliciting undesired immune responses, viral vectors are problematic because they can induce toxicity and cause insertional mutagenesis. Moreover, viral vectors do not transduce cancer cells efficiently and are hampered by immune responses that further limit their efficacy.

The development of non-viral gene-transfer technologies that can support stable expression in vivo is desirable. “Sleeping Beauty Transposon System” is active transposon used by scientists successfully in several cultured systems, including human cells and mouse embryos and offers a non-viral alternative approach for gene therapy.

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Therefore, it is of great interest to develop a non-viral gene therapy using the “Sleeping Beauty Transposon System” which could improve effectiveness of therapy by expressing therapeutic transgene into the target cells for long-term without causing pathogenic effect. The successful use of transposon technology for the nonhomologous insertion of foreign genes would be useful for cancer patients where they would improve effectiveness of therapy by expressing a therapeutic gene for long term and would avoid immunological reactions associated with viral vectors. The primary goal of this solicitation is to develop a non-viral “Jumping” Gene Therapy for neoplastic diseases, specifically breast cancer, prostate cancer, and ovarian cancer.

PHASE I: The objective of phase I is to demonstrate proof of principle for the effectiveness of “Sleeping Beauty Transposon System” which produces sufficient quantities of highly purified nonviral preparations containing the gene for one of the neoplastic diseases. This technology will have a strong potential for patenting.

PHASE II: The phase II studies must demonstrate ability to mediate therapeutic levels of gene expression for long duration in animal model of neoplastic disease using “Sleeping Beauty Transposon System”. Since it is not known when the recombinant nonviral vector containing the neoplastic gene introduced in vivo protein expression will be for how long and in what amounts in circulation and tissues, the phase II research will be dedicated for this purpose. Experimental animal, rodent (mice) will have tumor implanted for testing the delivery system. Protocol will involve delivery of nonviral vector containing neoplastic gene using i.v. or i.m. delivery system and examination of neoplastic gene expression/production in rodents (mice). The experimental animals will be examined for immune response. If the gene delivery protocol works, extend the studies to higher order animals and determine therapeutic dose window and prepare for clinical trials.

PHASE III: Pre-clinical studies and submission of IND. Manufacture pilot lot of test article under Good Manufacturing Conditions for human clinical trials. Gene therapy using this system will greatly impact both military and civilian populations not only for cancer treatment, but also for other disease treatments. Non-viral gene therapy may potentially be used to treat, cure, and ultimately prevent viral and bacterial diseases, obesity, wound healing, in the soldier’s battlefield environment. In addition, non-viral gene therapy system can be used to deliver the vaccines against infectious disease agents, biological and chemical agents in the soldiers. Also, this non-viral gene delivery system will be the most effective way of protecting the soldiers by introducing a bioscavenger in vivo for achieving long lasting protection against chemical warfare agents. The same process and advantage would apply for any first responders (civilians) reacting to terrorist attack.

REFERENCES:

KEYWORDS: Gene Therapy, Immunotherapy, Non-viral Vector, Cancer Treatment

A04-182 TITLE: Medical Simulation Training for First Response to Chemical, Biological, Radiological, Nuclear Events

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Expand and improve America's capability to provide medical first-response capabilities to chemical, biological, radiological, nuclear and high explosive (CBRNE) events through the research, development and commercialization of Medical Modeling and Simulation (MM&S) devices and / or training systems.

Develop and maintain disaster assessment/management, triage, diagnosis and treatment skills among military and civilian health care providers, first-responders and lifesaving self-aid and buddy-aid skills among laymen.
It has been recognized in the review of recent Medical Modeling and Simulation-related SBIR topic proposals that some businesses are on the verge of making breakthroughs in advanced computer simulation training systems such that the funding of an SBIR proposal would be sufficient to propel them into generating a successful product.

DESCRIPTION: Generally, we are looking for innovative ideas that explore and harness the power of multimedia computer game technologies such as avatar worlds, e.g. "sim games", that offer single or multi-player interaction via single computer, network or internet in simulated scenarios / worlds. User(s) could be presented with single or multiple challenges in scenarios that allow participation in, and response to, CBRNE events.

We seek tools that (1) engage the user(s) in a compelling, realistic simulation experience with ability to select an avatar ranging from layperson through first responder to the spectrum of healthcare and emergency service providers, (2) render human characters that are/will become casualties with functional anatomy and relevant physiologic functions, e.g., heartbeat, breathing, bleeding (3) have embedded metrics for time management, equipment/supply management, (e.g. finite supplies that must be renewed via realistic logistical means - these may be assessed as time penalties consistent with real-world situations), patient triage and transport management, (4) have embedded metrics for performance assessment and tracking of player actions and consequences, (5) include case scenarios that expose users to CBRNE events, (6) use online learning and updates, thus allowing for training and assessment from a distance (at a minimum any updates, testing and metrics should be assessable to instructors via internet, though application can be CD and web-based), (7) can function on multiple platforms to include PC, Laptop, PDA(if feasible) (8) have scenarios based on existing medical and pharmacological guidelines and standards, (9) allow unlimited practice by individuals and / or teams, (10) address the psychological considerations of users involved in virtual reality training / experiences who, even in a simulated environment, can respond negatively to disturbing events (consider game-based debriefing), (11) explore use of "intelligent tutoring" capability to take advantage of "teachable moments" for delivery of relevant curriculum, (12) explore use of virtual instructor technology, using Artificial Intelligence to potentially perform real-time assessment of users' strengths/weaknesses and alter scenarios accordingly. Of the noted requirements, all items except 11 and 12 are absolute.

The application will be compatible with Shareable Content Object Reference Model (SCORM) standards. (http://www.adlnet.org/) The training system will include embedded skill-assessment metrics to score technical performance. Training will be based on accurate, up-to-date information. System design will permit continuous improvement and upgrading.

PHASE I: Development of a concept plan and design for a prototype system to teach skills required by medical first-responders and laymen who may be called upon to assist in response to CBRNE events. Address the following items with respect to the Phase II requirements.

1. Describe and illustrate tool(s) under consideration
2. Model the proposed system configuration with respect to listed requirements
3. Identify medical learning content required/sources for curriculum

PHASE II:
1. Build the prototype system to address at least two character types, e.g. EMT/Medic, E.R. physician and at least one scenario from two threats, e.g., smallpox outbreak from Biologic threat and nerve agent incident from Chemical threat.

2. Embed metrics for performance assessment (including time and supply/equipment usage, patient outcomes-alive or dead) and tracking for at least the skills for which training certification is required.

3. Measure system performance under laboratory conditions. Compare results to current teaching methods.

PHASE III DUAL-USE APPLICATIONS: This capability will provide an immediate, increased capability throughout military and civilian medical communities, throughout civilian law enforcement and emergency communities, and among community healthcare care providers such as school and community clinics. The
production simulation training devices / systems have potential widespread application to numerous medical first-responder events in which the trainee becomes the care provider.

REFERENCES:
1. SCORM-accessed at http://www.adlnet.org

KEYWORDS: medical simulation, advanced distributive learning, medical skills training, metrics, combat medic, trauma, emergency medical technician, performance assessment, first responder, virtual worlds, avatar, intelligent tutor

A04-183 TITLE: Broad-spectrum Prophylaxis for Infectious Diarrhea in Deployed Military Forces

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Identify and evaluate a single-entity or combination non-vaccine, non-antibiotic oral agent that prevents, with high efficacy but low adverse reactogenicity and toxicity, infectious diarrhea in deployed military forces caused by a wide variety of etiologic organisms endemic to possible deployment areas.

DESCRIPTION: One of the largest contributors to diminution of combat effectiveness due to disease and non-battle injury in deployed military forces is endemic diarrheal disease. Although rarely fatal, diarrheal diseases result in significant loss of duty days, degrading operational competence and burdening the organic medical care capabilities of the force. The etiologic agents of infectious diarrhea include a wide variety of microbial organisms (viruses, bacteria, parasites) that produce their effects through a multitude of biological mechanisms, thus thwarting simple preventive measures. With the exception of Ty21A vaccine for typhoid fever, no vaccine against the major known agents of diarrhea have been successfully developed, including those for various Salmonellae and Shigellae species, cholera and enterotoxigenic E. coli, Norwalk virus, Giardia lamblia, and a host of other prokaryotic and eukaryotic microorganisms. The diverse molecular mechanisms by which these organisms exert their diarrheagenic responses have restrained traditional pharmacologic approaches to prophylaxis and disease intervention. Certain antibiotics can provide limited agent-specific treatment, but often fail because they target an organism that is largely absent once the cascade of molecular events (often stimulated by a secreted microbial toxin) has produced diarrheal symptomatology. Moreover, the use of antibiotics for long-term prophylaxis suffers from the twin dangers of adverse reactions and the possible selection of resistant organisms. Antimotility drugs, such as Lomotil, can reduce fluid loss but do not preclude infection and may delay the seeking of definitive treatment. Probiotics (e.g., non-pathogenic enteric organisms) have given variable results in limited clinical studies. Only bismuth subsalicylate (e.g., Pepto-Bismol) has demonstrated relatively broad-spectrum protection with an acceptable safety profile consistent with OTC drugs, but must be taken in multiple daily doses and the effectiveness of long-term use has not been adequately explored.

PHASE I: Identify known or proposed chemical or biological agents having the potential to protect against diarrhea in deployed US forces. Such agent or agent combinations should be selected with the following prospective characteristics to be tested in Phase II studies: non-immunizing, non-antibiotic, broad-spectrum effectiveness
against a variety of important endemic diarrheagenic organisms to include (at a minimum) enterotoxigenic Escherichia coli, Shigella spp. and Campylobacter spp., a known or suggested safety profile similar to over-the-counter (OTC) medications, effectiveness over extended periods (greater than or equal to one week) with minimal dosing (less than or equal to once a day), capable of oral delivery, and stable under field conditions.

PHASE II: In appropriate animal models, evaluate safety and effectiveness of the identified agent or agents against militarily-important diarrheagenic organisms when given in various combinations, dosing schedules, and for extended periods of time.

PHASE III DUAL USE APPLICATIONS: Establish effective commercial partnership(s) that will enable clinical testing of prototype agent or agent combinations under conditions suitable for consideration by US military forces. The agent or agent combinations, if effective, would also be useful in civilian populations, such as traveller's to endemic areas.

REFERENCES:

KEYWORDS: diarrhea, military operational significance, prophylaxis, broad-spectrum, non-vaccine, non-antibiotic, oral, high efficacy, OTC safety profile

A04-184 TITLE: Hemorrhage Control for Non-Compressible Extremity Injuries

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Develop a small device capable of controlling hemorrhage from vascular injuries in the proximal extremities. The device will be used on injuries that are not amenable to tourniquet application and will be used at the level of the combat medic.

DESCRIPTION: It is estimated that 10% of the soldiers killed on the battlefield bleed to death from extremity wounds (1,2). Many of these lives could be saved by the prompt and effective use of a tourniquet (2). However, a subset of extremity injuries occur at a level that is not amenable to tourniquet application. Vascular injuries in the region of the groin continue to be largely untreatable on the battlefield (2).

There is a need to develop new devices that can meet this need. Such devices must be usable at the level of the combat medic. Effective use of the device must be obtainable under the conditions of the tactical environment, i.e., dark, wet, hot, cold. The device must be able to work in the fully transected, retracted, femoral artery. Currently the only way to address this is by exploring the wound site, locating the artery and clamping it with hemostats. A devise must aid in the isolation and occlusion of the artery or alternatively function without requiring the isolation of the artery.

PHASE I: Identify a device or technology that can be used to control hemorrhage in the groin and demonstrate its feasibility in a (non-animal) model system.

PHASE II: Test efficacy of device in large animal experiments using a fatal groin injury model.

PHASE III DUAL USE APPLICATIONS: Death as a result of severe vascular injury to the groin is not limited to military trauma. The development of this technology will potentially result in life savings in both military and civilian trauma settings.

REFERENCES:

KEYWORDS: Hemorrhage Control; Tourniquet; Extremity Trauma; Vascular Trauma

A04-185 TITLE: Automated Interactive Coping Skill and Resiliency Tool

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: To develop, implement, and evaluate an automated educational tool intended to strengthen family functioning and enhance coping skills and resilience in military members during periods of prolonged family separation.

DESCRIPTION: This topic proposes to create, validate, and test a self-administered educational program tailored to address military service-related relationship and family problems. Relationship and family problems are risk factors for mental health conditions such as depression (Beach, Smith, & Fincham, 1994). Studies also indicate these problems are associated with work loss and decreased productivity and job satisfaction (Adams, King, & King, 1996). These associations are particularly relevant in men in their first decade of marriage (Forthofer & Markman, 1996), a period very significant for military personnel exposed to deployment stressors. Research on military families and veterans indicates that these groups are at risk for increased difficulties in intimate relationships and reduced family cohesion (Jordan et al., 1992), and that these factors adversely impact performance. (Raschmann, Patterson, & Schonfield, 1990). Studies also indicate that social support ameliorates the effects of deployment-related stressors (King, King, Fairbank, Keane, & Adams, 1998), and that, for partnered couples, the most important source of social support is the spouse or partner. Relationship and family problems are likely, therefore, to significantly reduce a soldier's ability to cope with stressful situations during deployments, impair job performance, and interfere with mission accomplishment. Existing relationship problems that are exacerbated by separation or deployment stresses are likely to not only impact resilience during deployment, but also may adversely affect later adjustment and job performance in the post-deployment period. In addition to the effects such difficulties have on performance in the military, they are also, anecdotally, related to retention problems in active, reserve and guard components of the military and may, therefore, present an additional and significant obstacle to efficient and successful military functioning.

Computerized educational training programs are a rapidly growing phenomenon for providing, on a self-help basis, improvement in coping skills of individuals in specific areas. These programs provide returns in terms of enhanced quality of life and work performance for the individual and have a positive impact on the individual's performance in their day-to-day activities. No computerized intervention has yet been specifically designed to provide training to improve both dyad and individual coping skills and resilience under stressful conditions, though some recent research demonstrates the efficacy of automated interventions among samples of civilian couples (Beer & Breuer, 2002). An educational tool, based on identifiable military performance problems resulting from weaknesses in dyadic or family functioning, is a low cost means of enhancing performance among service personnel during periods of stress imposed by military duties. There are obvious advantages to such programs, including the ease and potentially wide scope of implementation, as well as enhanced cost-effectiveness. It is also likely that such programs can be carried out in the off-duty setting, circumventing numerous potential barriers to participation.

PHASE I: In Phase I a determination of the feasibility and potential of the intervention is made. This involves identification of relationship and family problems that potentially impact on military functioning, the determination of mechanisms for resolution or amelioration of difficulties that are amenable to instructional correction, and the development of a detailed plan for Phase II. As part of the plan, access to a study population will be obtained, as demonstrated by letters of support from key military personnel, and human studies approval will be sought.
PHASE II: In this phase the efforts achieved during phase I will be further refined and exploited. Identified mechanisms will be translated into content, format, and mode for the automated intervention. Specifically, mechanisms for the amelioration of difficulties identified in Phase I will be translated into a computer-based educational program that can enhance family functioning in both the pre-separation/deployment period and the post-separation/deployment period. The tool will be optimized for resolution of specific strains on family functioning and their effect on military performance. The final product, the intervention prototype, will be piloted in Phase II for relevance, interest, ease of use, and user satisfaction. Importantly, preliminary efficacy will be demonstrated via more immediate impact on family functioning with evidence for more distal impact on military performance. Additionally, the evaluation design and sampling plan will be finalized for a broader testing of the intervention in Phase III.

Phase III DUAL USE APPLICATIONS: The intent is to improve dyadic and family functioning that affects military performance and well-being. The automated educational tool will be evaluated using an experimental or credible quasi-experimental control-group design that can rule out potential confounding factors. Both objective and subjective measures of military performance, disciplinary or problem behaviors, and health and adjustment will be considered. Further assessment of ease of use will be accomplished. The tool will be refined for ongoing military applications and modified to support civilian applications, where populations are similarly affected by either prolonged separations or through participation in potentially life threatening professions (e.g., firefighters, police officers, and other emergency and safety personnel; personnel in multinational organizations deployed to hazardous or underdeveloped regions).

REFERENCES:

KEYWORDS: resilience, coping skills, dyad function, stress and job performance

A04-186 TITLE: Development of a Viral Based Gene Delivery System for Chemical Agent Bioscavengers and Biological Agent Vaccines

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: The Army has a need for a system for the delivery of chemical agent bioscavengers for the protection against chemical warfare agents (Soman, Sarin, VX, and Tabun) and category A biological warfare agents (Botulism, Anthrax, Plague, Tularemia, and Ebola). The objective is to develop a suitable viral based gene delivery system for delivering a bioscavenger such as human serum butyrylcholinesterase (Hu BChE) into humans.
to afford protection against nerve agent and pesticide poisoning. In addition, the same delivery system may be used as delivery platform for vaccines against biological warfare agents.

DESCRIPTION: Hu BChE is a drug candidate for the detoxification of certain harmful chemicals to warfighters, including organophosphorus (OP) chemical warfare agents (1-4). Mechanisms of OP induced toxicity and BChE detoxification of OP compounds are fairly well understood. It is estimated that humans will require ~200 mg (3 mg/Kg) of Hu BChE to protect against an exposure of up to 2 LD50 of Soman (5, 6). Purification of native Hu BChE in sufficient quantities to administer to tens of thousands of soldiers is tedious and expensive. Currently, native human plasma is the source of Hu BChE and availability of human plasma is very limited. It is more urgently required for medical emergencies rather than purification of Hu BChE. Therefore, it is imperative to develop cost effective alternate methods of producing Hu BChE in vivo for the administration of protein-based prophylactics and therapeutic drugs.

The military relevance for developing alternate delivery platforms is mandated in DTO CB32 (Title: Alternate delivery methods for recombinant protein vaccines) and DTO D (Title: Chemical Agent Bioscavengers). As stated in their program plans, the objectives are to evaluate respiratory vaccination and oral as well as transcutaneous delivery for recombinant vaccines and delivery of bioscavengers via gene therapy.

Gene therapy is emerging as an approach to achieve high-level expression of proteins in vivo that are very similar to their native counterparts. A variety of viral vectors and their constructs including adeno, adeno associated, vaccinia ankara, lenti, and pox are undergoing pre-clinical and clinical testing for gene therapy purposes. Recently, these viral vectors have also been under development as delivery platforms for vaccines against cancer, neurological and infectious diseases. In order to utilize viral vectors as delivery platforms for gene therapy and vaccines, they have to be: (A) safe to be injected in vivo and do not cause any long term health complications, (B) deliver the DNA to the intended tissue, and (C) achieve long term expression of the desired gene product in the intended tissue such that the treatment regimen is patient friendly. Based on these recent developments in viral vector technologies, we anticipate that a suitable viral vector containing the gene for Hu BChE can be used as a delivery platform for delivering a bioscavenger for chemical warfare agents.

We envisage that viral vector mediated gene therapy based approach to introduce Hu BChE as bioscavenger in vivo offers several advantages over the administration of recombinant or native BChE protein. (A) While recombinant and native BChEs come in contact and inactivate circulating OP, BChE introduced via a viral vector can inactivate both circulating and tissue absorbed (at the neuromuscular junction) OPs. Thus, using a suitable viral vector based gene delivery platform, bioscavenger can be introduced not only in circulation but also at the site of OP injury i.e at the neuromuscular junctions. (B) In contrast to native BChEs which have a half-life of few days to a maximum of two weeks, Hu BChE gene introduced in vivo using a viral vector can be active for 3 to 6 months as has been demonstrated for other genes (7). Thus, repeated injections of Hu BChE are not needed using the viral vector mediated gene delivery approach. (C) Viral vector containing Hu BChE gene can be administered as aerosol as has been utilized in cystic fibrosis study (8). Thus, gene therapy based approach could be adapted into a non-invasive pulmonary delivery system for the warfighter and the civilian population.

The availability of a viral vector based gene therapy system will lead to increased operational efficiency since there will be no need to carry around or wear protective clothing. This is important for soldiers in the battlefield, for marines guarding USA Embassies, and first responders that must enter an area of exposure.

PHASE I: This phase will be to determine feasibility. The goal will be to develop suitable viral vectors inducing long-lasting expression of Hu BChE protein in mammalian celllines including liver, lung, muscle, and nerve.

PHASE II: Since it is not known when the recombinant viral vector containing the gene for Hu BChE introduced in vivo BChE protein expression will be for how long and in what amounts in circulation and tissues, we suggest that Phase II research will be dedicated for this purpose. Protocol involves delivery of viral vector containing Hu BChE using i.v or i.m or needleless delivery system and examination of BChE expression/production in rodents (Guinea pigs)/non-human primates by suitable biological and chemical methods (9). The safety of the animals injected with the recombinant virus may be determined following serum chemistry, hematology parameters, and histopathology where possible. Whether or not Hu BChE mounted any immune response in experimental animals needs to be
addressed in Phase II studies. The studies will involve testing the efficacy of this viral mediated gene therapy platform as a bioscavenger by exposing Guinea pigs and non-human primates to OPs or pesticides.

PHASE III DUAL USE APPLICATIONS: The development of a viral vector based Hu BChE gene will likely lead to state of the art technology as a delivery platform for bioscavengers against nerve agent toxicity. We anticipate that a single injection of the recombinant virus containing the gene for Hu BChE will be sufficient to produce high expression levels of Hu BChE in circulation and tissues for very long periods of time (2 to 6 months). If that has been the case, viral mediated delivery of Hu BChE will be the most effective way of protecting the soldiers from nerve agent toxicity. Prior to entering the combat zone, the soldiers will receive recombinant virus via i.m or i.v or needleless delivery as an inhaler (10, 11) so that they can be protected in the event of a chemical agent attack. If successful, this form of pretreatment strategy against nerve agents causes no weight penalties, behavioral alterations, or performance reductions to our soldiers (1-4,12). The same process and advantages would exist for any first responders (civilians) reacting to terrorist nerve gas release/attack or cocaine overdose, pesticide overexposure, or succinylcholine-induced apnea (13). The viral vector gene delivery platform could also be utilized for the delivery of vaccines against category A biological warfare agents including botulism, plague, ebola, and tularemia.

REFERENCES:

KEYWORDS: bioscavengers, human, butyrylcholinesterase, viral vector, gene therapy, organophosphorous chemical agents, pesticides, biological warfare agents, cocaine, vaccines

A04-187	TITLE: Developing Nanotechnologies for Detection and/or Targeted Treatment
TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Identify, design and develop a nanotechnology for the detection and/or treatment of cancer.

DESCRIPTION: Ovarian cancer ranks second among gynecological cancers in the number of new cases, and first among gynecological cancers in the number of deaths each year. In 2003, approximately 24,500 women will be diagnosed with ovarian cancer in the United States alone, and 14,300 will die from the disease. Ovarian cancer is often without overt or specific symptoms until late in its development; therefore, most women are diagnosed with advanced stage disease. As a result, women diagnosed with ovarian cancer have a 5-year survival rate of only approximately 50 percent. However, local ovarian cancer has a 95 percent 5-year relative survival rate, thus emphasizing the need for early diagnosis (1).

Nanotechnology, the creation of devices, instruments, structures, and systems whose size ranges from 1 to 100 nanometers and who exhibit novel physical, chemical or biological properties because of their nanometer size is beginning to have a major impact in all areas of science and technology. Nanotechnology is currently and probably will continue to emerge as an important catalyst in information technology, medicine and health, materials and manufacturing, aeronautics and space exploration, energy and environment, transportation, and national security (2). These nanotechnologies include but are not limited to nanopores, nanotubes, magnetic nanoparticles, quantum dots, nanoshells, and gold particles (2, 3, 4, 5, 6, 7).

The fields of nanotechnology, biotechnology and medicine have converged to produce many potential biological applications. Some of the applications include detecting minute traces of disease such as cancer, or detecting a single spore of a pathogen, diagnosing complex diseases more accurately, screening potential drug candidates rapidly and efficiently, developing targeted therapies and vaccines that enhance efficacy but reduce toxicity (3, 4, 5, 6, 7, 8, 9). One example of a biological application of nanotechnology is the use of quantum dots (“tunable”, fluorescent semiconductor nanocrystals that are excited by a single light source and have a broad excitation spectrum) for imaging cells and tissues such as frog embryos in vivo (10) and both cardiac vessels and the heart in mice in vivo (11). Another innovative example of the convergence of nanotechnology with medicine is the recent research & development effort by West and Halas (12, 13, 14). These researchers have recently shown that nanospheres, like quantum dots, have “tunable” optical properties, and have great potential as tumor-specific drug delivery vehicles and targeted-time released therapy.

Nanotechnology has the potential to revolutionize medicine – it is estimated that by 2015, nanotechnology-related systems in healthcare areas such as bioimaging, biosensors, tissue regeneration, targeted drug/vaccine delivery, and targeted drug/vaccine release, could represent up to $180 billion annually (9). Thus, nanotechnology has the potential to revolutionize both detection and therapeutic methodologies of disease. The primary goal of this solicitation is to develop nanotechnology for the detection and/or treatment of ovarian cancer. Given the military need for both ultra-sensitive detection of biological and chemical agents and agent/pathogen-targeted treatments, the transfer of technology to these areas should be realized.

PHASE I: Identify and outline the feasibility and applicability of using one or more nanotechnologies for either the detection or treatment (or both) of ovarian cancer. Specifically, identify, describe and outline the feasibility of conjugating proteins or peptides or antibodies or carbohydrates specific to ovarian cancer to a nanomaterial/nanotechnology and the associated imaging system for detection of ovarian cancer. Further, identity, describe and outline the feasibility of at least one nanotechnology system that would deliver in vivo, targeted therapies to ovarian cancer cells.

PHASE II: Design, develop and optimize at least one specific nanotechnology for either the detection or treatment (or both) of ovarian cancer. A nanotechnology with the conjugated proteins or peptides or antibodies or carbohydrates specific to ovarian cancer and the associated imaging system for detection of ovarian cancer should be developed and optimized, and effectiveness of said system should be demonstrated in an appropriate animal model. Further, at least one nanotechnology system that would deliver in vivo, targeted therapies to ovarian cancer...
cells must be developed, and its efficacy demonstrated in an animal model. The demonstration of effectiveness with a specificity and sensitivity of 95% as either a detection method or therapy should be demonstrated in an animal model.

PHASE III DUAL USE APPLICATIONS: Perform additional experiments with the nanotechnology for FDA approval for clinical trials and commercialization. Perform clinical trials. Early detection of and/or an improved treatment for ovarian cancer is needed to best care for the military personnel, their beneficiaries, and the public-at-large, and to reduce the health care costs incurred in treating and caring for these individuals. In addition, this technology has numerous other military applications having great potential to improve battlefield situational awareness. These applications include but are not limited to, detection and eradication of infectious diseases, detection and treatment of biological and chemical agents in the environment, treatment of burns and tissue replacement, fibre bandages, atmospheric communications, image reconstruction and detection, night vision, detection of land mines, and detection of obscured targets.

REFERENCES:
3) Nanotechnology and Medicine, http://www.users.muohio.edu/baileybr/discussion.htm
7) Schechter, B, New Scientist, April, 31-33, 2003.
13) Halas, N, oeMagazine – The International Society for Optical Engineering; http://oemagazine.com/fromTheMagazine/dec01/tinybutmighty.html

KEYWORDS: nanotechnology, quantum dots, nanospheres, cancer detection, cancer treatment, targeted therapies

A04-188 TITLE: Fatigue and Performance Modeling of Sleep-Deprived Soldiers

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Develop biomathematical computational models to predict the impact of fatigue, sleepiness, and countermeasures on soldier performance.

DESCRIPTION: Fatigue and reduced sleep can adversely affect cognitive function of soldiers in the battlefield, leading to reduced performance or even death (e.g., friendly fire). The impact of fatigue and sleepiness on soldier performance, however, could be mitigated if we were able to develop tools to optimize performance management. For example, such tools could be used to establish sleep schedules in order to optimize soldier cognitive state during scheduled military operations or could be used to determine the precise time and amount of countermeasures (e.g., naps, caffeine, and other drugs) that result in performance peaks at the desired time and that can safely prolong peak performance.

A recent international workshop, co-sponsored by the Department of Defense, was organized to assess the state-of-the-art of biomathematical models of fatigue, sleepiness, and performance; identify conceptual and technological barriers to these models; and identify and communicate research needs in military and civilian applications [1].
of the key findings of the workshop is that the current generation of models is based on small variations of the two-process model of sleep regulation proposed by Borbely [2], which was derived for modeling sleep regulation and not to predict human performance and assess accident risk that are the objectives of the models described in the workshop. Hence, it is not surprising that there was not great variability in model performance; one model performing better in one scenario and worse in another.

Another finding is that previously identified [3,4] critical gaps in fatigue and performance research still remain unanswered. In particular, there is a need to develop models that:

1 - Predict individual performance (in addition to group-average performance).
2 - Provide quantitative, objective statements of the reliability of the model predictions, such as statistical error bounds in the form of standard error, confidence intervals, and prediction intervals.
3 - Are systematically validated and quantitatively characterized so that it can be determined, a priori, to what set of scenarios/conditions the models are applicable and where they are inadequate and fail to predict performance.
4 - Predict the effect of performance-enhancing and wake-promoting countermeasures, such as prophylactic naps and substances like caffeine and pharmacological drugs.
5 - Make use of performance metrics (i.e., model outputs) that have close ties to real-world, military relevant mission activities as opposed to simple response-time metrics, such as the commonly used Psychomotor Vigilance Task (PVT).

This solicitation seeks an integrated research plan that addresses at least one of the research gaps identified above and follows a conventional life-cycle model development protocol where models are systematically developed, validated, and refined to provide a comprehensive explanation of the underlying mechanisms of the observed phenomenon. This may include the iterative development of biomathematical models coupled with experimental laboratory/real-world validation tests. This solicitation does not seek minor refinements of existing models; by the incorporation of additional model components or fitting of model parameters; so that the differences between predicted and observed values are minimized for one particular experiment without really improving model generalization capabilities where new, unanticipated scenarios/conditions can be accurately predicted. Rather, it is soliciting innovative ideas [5] necessary to address the research gaps outlined above. The government will provide existing experimental data.

PHASE I: Conceptualize a comprehensive research plan, including model development, refinement and validation tests as well as corroborating laboratory/real-world experiments that addresses at least one of the research needs identified above. Conceptualize and develop early software prototype that demonstrates proof-of-feasibility of the proposed approach. For example, to incorporate the effects of countermeasures one could: (1) identify the required experiments, (2) attain results from already performed laboratory experiments, (3) propose additional experiments, (4) identify a robust computational framework for model development, (5) identify systematic model validation tests, (6) identify performance metrics, and (7) provide an indication (based on early prototype, readily available data or open-literature results) that the proposed modeling framework has sound development and investment potential. The goal of the Phase-I effort is to perform the necessary research to demonstrate proof-of-feasibility of the proposed approach.

PHASE II: Extend the concepts developed during the Phase-I effort. Perform laboratory/real-world experiments as needed to develop fully operational models. Perform comprehensive model validation tests. Phase-II deliverable should be a fully developed and demonstrated model.

PHASE III DUAL USE APPLICATIONS: This set of computational tools will have both military and civilian applications. Civilian applications range from shift-work scheduling to minimize accident risk to predicting performance of truck drivers. The Phase-III effort shall include thorough validation of the algorithms with real-world performance data.

REFERENCES:
4) J. Reifman and P. Gander, "Commentary on the Sleep/Wake Predictor Model and Broader Modeling Issues", accepted for publication in the Special Supplement to Aviation, Space, and Environmental Medicine, (in press).

KEYWORDS: fatigue modeling, sleep modeling, performance prediction.

A04-189  TITLE: High Throughput Genomics Screening for Malaria Antigen Discovery

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Design a system using vectored viruses or other technologies to screen large numbers of proteins derived from the malaria genome project for their ability to generate antigen-specific immune responses and confer protection in animal or human subjects.

DESCRIPTION: The Malaria Genome Project has resulted in the identification of over 5,200 genes, many of which are likely to be involved in substantial protective immunity to infection with malaria parasites. High throughput proteomics has uncovered the patterns of expression of thousands of proteins from various stages of the parasite life cycle and bioinformatics approaches can predict protein function and subcellular location. Effective malaria vaccines will depend on the ability to generate both humoral and cellular immunity against parasite proteins expressed a multiple stages of the parasite life cycle. Two models of malaria vaccines suggest that development of an effective malaria vaccine is feasible. The irradiated sporozoite vaccine confers sterile protective immunity against sporozoite challenge in human volunteers lasting at least nine months and is likely directed at parasite proteins expressed at the liver stage of parasite development. Naturally-acquired immunity results in individuals, usually children, who live for years in malaria endemic areas of the world and who are likely to develop antibodies to parasite proteins expressed by the blood stages of parasite development. Whether any of the antigens currently selected for malaria vaccine testing are those that result in the protective immunity is not yet known. Efforts are needed to develop high throughput mechanisms to screen the malaria genome for antigens that are able to confer substantial protection in humans or to generate improved immunogenicity over the antigens in the vaccine development pipeline.

PHASE I: Develop overall system design that includes the ability to manipulate Plasmodium genes into immunological systems. The designs provide will have to be readily achievable with existing basic technology, viral vector systems and cloning systems. Proof of concept with one or few antigens will be required.

PHASE II: Develop and demonstrate a prototype a system that is capable of delivering large numbers of genes or proteins into antigen presenting cells that are capable for use in in vitro and/or in vivo immunological assays and protection studies. This Phase will demonstrate the integration of large scale viral vectors into immunologic screening assays to prioritize for inclusion in vaccine development efforts. The program should identify a self contained method with reagents for potential commercialization.

PHASE III DUAL USE APPLICATIONS: The fundamental first principle in the development of effective vaccines is in the identification of proteins which are responsible for protection. This is true whether the vaccine is developed by the military or by commercial ventures. For all subunit vaccines, this antigen identification process can consume substantial resources and time. A successful SBIR proposal will provide for a means to identify and down-select from many thousands of proteins in an organism to those few which are responsible for protective immunity. The military would utilize this approach for antigen selection across both the Infectious Disease Programs and in the Biowarfare Defense Programs. An example would be the identification of protective antigens in Francisella tularensis from the F. tularensis genome and incorporation into molecular vaccine technologies. Commercial applications include the identification of protective antigens from Helicobacter pilori and their
incorporation into a DNA-based vaccine that would be commercially available. Further, if successful, the small
business developer of this approach to antigen identification would be able either to sub-license the technology to
big Pharma, or to provide a service in the generation of candidate vectors in the genomic screening process.

KEYWORDS: Malaria, vaccine, proteomics, antigen discovery, recombinant virus, functional genomics

A04-190 TITLE: Antimicrobial Bone Graft Substitute

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: A synthetic bone graft substitute that is antimicrobial and/or enhances bone fracture healing is needed
by the military. The bone graft substitute will, ideally, replace the use of bone cement impregnated with an
antibiotic and the need for an autograft. This would minimize the total amount of surgeries, cost of procedures, and
morbidity of the patient.

DESCRIPTION: Open fractures account for approximately 20% of all combat-related injuries in soldiers. These
open fractures pose a greater problem to a military surgeon and result in higher morbidity to the soldier than those
seen by a civilian counterpart. The military surgeon often encounters open fractures from missile injuries that
involve large bone defects with inadequate soft tissue envelopes and concomitant neurovascular injuries. Battlefield
injuries experience greater evacuation time from the moment of injury to treatment, resulting in contaminated
wounds becoming infected.

The current standard of care for open fractures involves irrigation, debridement, appropriate initial stabilization, and
antibiotic therapy (1). Polymethylmethacrylate (PMMA) is routinely combined with gentamycin or tobramycin,
rolled into beads, and placed in the bone defect in order to provide local antibiotics through elution and fill dead
space. These antibiotic impregnated beads may remain in the wound for several weeks. Although effective in
treating infection, these cement beads are not bioabsorbable and will eventually retard bone growth; therefore, they
must be removed during another surgical procedure(2,3). These factors increase patient morbidity and cost of total
treatment. Further, definitive treatment requires an additional surgical procedure to graft bone, traditionally obtained
from the iliac crest, to fill the void. The ideal bone graft substitute would treat infection (using an antimicrobial
instead of an antibiotic), promote fracture repair, and not require additional surgical procedures.

PHASE I: Identify and select candidate antimicrobial agents, select target bacteria, and establish minimal inhibitory
concentration test methodology. Staphylococcus aureus, Acinetobacter, Klebsiella, and Pseudomonas aeruginosa are
commonly present in infected wounds. Concurrently, an animal cell culture model for measuring cell viability
(cytotoxicity) and osteoinduction (if appropriate) will be established for proof of concept. This will be used to
evaluate antimicrobial candidates for both antimicrobial activity and for effects on cultured cells.

PHASE II: Phase II will culminate in a prototype that will demonstrate that the product is non-toxic to the host tissue
and has antimicrobial ability in a contaminated bone defect animal model. These studies will support the transition
from pre-clinical to clinical trials.

PHASE III DUAL USE APPLICATIONS: Clinical trials to support FDA approval is required for use by medical
doctors in both settings. This product has dual use because both military and civilian medicine would benefit from
it. Open fractures commonly occur in the civilian setting by motor vehicle accidents, but gun shot wounds and
heavy equipment accidents also are causes of open fractures.

REFERENCES:
108.

KEYWORDS: bone, infection, fracture, repair,

A04-191 TITLE: Soldier Mounted Eye Monitor

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Primary objective is for a device capable of capturing gaze, pupil, and saccadic movements in each eye individually, simultaneously, at a high frequency, preferably through fiber optic technology. A second objective is to detect point of fixation of eyes. The intent is for an extremely lightweight and rugged “eye capture” system that can mount onto helmet, headgear, or spectacles, with a capability of providing a minimum of two synchronized eye data streams into a remote computer.

DESCRIPTION: The eyes provide both a means by which the soldier may be monitored, and a mechanism by which the soldier may potentially exert control over aspects of his/her environment. Impairments in pupils and eye movements are seen with fatigue and sleepiness, medication use, toxin exposures and have been shown to precede performance failures. The initial intent for the requested system would be to capture saccadic eye movements, eyelid movement, and pupil size changes for purposes of integrating into a physiological monitoring array. A second intent is to obtain the point of fixation for the purposes of targeting and for potentially turning on/off pre-selected instruments when the hands and voice are not available. This system would provide a means through which some controls could be operated by the eyes (rather than by the hands or voice). The system will require controls to monitor for variation or disruption in binocular vergence or fusion. This may be accomplished through the incorporation of measurements of accommodative state, vergence state, or other methods of verifying ocular fixation and alignment. The ultimate goal of this SBIR is to develop an eye capture system that could integrate into a monitoring system to assess for and predict potential impending operational performance failure.

PHASE I: The contractor will provide a proof of concept design using emerging technologies for a head- or helmet-mounted device that measures specific eye activities. The design would connect the sensor array to a remote panel (off the shelf - not to be developed as part of this SBIR) so that data will integrate with standard physiological databases. Algorithms and software would be planned so that data streams would be synchronously collected. The design should aim for a head- or helmet-mounted device to be light-weight and ruggedized, capable of operating under environmental extremes compatible with human endurance, and compatible with existing aviator headgear. Neither prototype delivery nor human testing will be required. The design should provide for the capability of capturing eyes of all shapes and sizes, and capture pupils 3mm and larger under both low-light (less than 5 foot candles) and sunlight (10,000 ft-cdls) ambient illumination levels. Saccadic eye movement data should be captured at a frequency of at least 500Hz through the full visual field range. Among the oculometric measures of interest for software development purposes are peak saccadic velocity, pupil diameter, location of pupil (Tracking), percent of eye open/closed, percent cornea exposed.

PHASE II: In the first half of Phase II, a single prototype experimental device from the initial design approved in phase I will be provided. Technical challenges the contractor would need to overcome include the engineering of the eye capture mechanism so as to make it light weight, rugged, and capable of synchronously capturing from both eyes oculometric measures at high frequency. The contractor will write and provide eye capture and data streaming algorithms and software to integrate the eye capture mechanism with a physiological database with this initial prototype. In the latter half of phase II, the contractor will test techniques for ruggedizing the device. In phase II, the device will undergo human testing in laboratory-based simulators. Collaboration between primary and subcontractors is encouraged. Contractor independence and need for contractor intellectual contributions are
emphasized. The device will undergo initial Airworthiness Certification testing and assessed for use in field trials. Human use studies will be performed through an already approved USAARL protocol.

PHASE III DUAL USE APPLICATIONS: Application of the device for use by pilots in commercial aircraft would begin with FCC evaluation and testing. Application by commercial railroad industry engineers and by commercial truckers would begin with DOT evaluation and testing. Potential use by all operators of high performance, long-haul-capable vehicles, including automobiles, would begin after Federal agency evaluation and approval.

REFERENCES:

KEYWORDS: gaze, pupil, saccade, eyes, monitoring, tracking, sleepiness, fatigue, performance assessment, performance prediction, control

A04-192 TITLE: Novel Protein Nanodelivery Systems for Biological Agent Countermeasures

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: To develop nanometer sized capsule materials that are fully water soluble, non-toxic and non-immunogenic (< 200 nm in diameter) capable of delivering proteins of interest effectively with sustained release capability for chemical and biological agent countermeasure.

DESCRIPTION: The anthrax attacks in the United States, shortly after the September 11 terrorist attacks on New York and Washington, DC, have made a theoretical bioterror hypothesis a stunning reality. In addition to early diagnostic tools, the appropriate vaccines, antidotes, and therapeutics are also very important for aftermath treatment and disaster management. There is an urgent need to develop and evaluate new therapies for anthrax. The current AVA vaccine consisting of aluminum hydroxide adsorbed PA (protective antigen) of a toxigenic, non-encapsulated strain of B. anthracis, V770-NP1-R, has shown protection in animal exposure models. Likewise newer vaccine candidates using PA have shown strong protective immunogenicity. Use of nanoparticles to deliver these antibodies immediately post infection is an avenue that has not been explored in the past. This will allow fast and effective
therapy post exposure in place of regular antibiotics which takes time and have tremendous side effects as observed recently after CIPRO administration to patients.

Although some small molecule drugs such as CIPRO have shown reasonable effectiveness during early phases of clinical treatment, their use is often limited to early stages of the infection. The protein-based therapeutics are expected to have much broader applications for late stages in the areas of chemical and biological countermeasures. However, there are certain limitations of using these protein based therapies; the proteins are unstable in the blood stream, they often exhibit severe immunogenic effects. Therefore, there is a strong need to develop novel nanomaterials that will allow us to deliver proteins in a well controlled manner. In many cases, a long term protection of proteins in the blood stream or a sustained release of proteins is required, we hope these novel materials will allow us to do that. The ideal delivery vehicle should be monodispersive and range from 10 to 200 nm in diameter. Such nanomaterial delivery vehicle should be completely water soluble and capable of encapsulating proteins in biological buffers using simple experimental procedures. The process involving encapsulating proteins using organic solvents should be avoided since it tends to denature protein molecules. We also do not choose to have a liposome based delivery system.

The aim of this project is to utilize nanometer size capsule materials to deliver specific antibodies or other antidotes targeting B. anthracis spores/toxins. The encapsulated antisera/antidotes contained within the nanoparticles can be aimed at PA (protective antigen), LF (Lethal factor) and or spore components. The goal is to use these reagents to capture, sequester and eliminate the bacteria or its toxins from the lungs, spleen and lymph nodes. Nanoparticles can carry protein molecules that will bind to a toxic agent wherever it may be in the body.

The ability to encapsulate recombinant proteins and show effectiveness in vivo is very crucial for this development. Protein carriers that are capable of generating long-term circulation of therapeutic proteins can provide numerous advantages such as enhancing the efficiency of controlled-release drugs, providing site specific protein delivery, as well as reducing the need for repetitive injections or administrations.

These nanoparticles will revolutionize the way we think of treatment today, it will make it much more specific and effective way of delivering therapeutic materials into the body. If successful, such nanocapsule protein delivery systems could also find broad applications in the areas of biodefense and infectious disease prevention and treatment.

PHASE I: Develop synthetic methodology, synthesize a variety of monodisperse nanomaterials, demonstrate the feasibility of encapsulation with recombinant proteins that can be delivered inside a cell without degradation. The proposer must demonstrate the effectiveness of nanoprotein delivery system with relevant recombinant proteins for biological agent countermeasure applications which will be evaluated in the in vitro macrophage cell culture assay system. Optimized compositions and formulations showing effective delivery of intact proteins in cell culture will be considered for phase II funding.

PHASE II: Optimize the proposed nano protein delivery systems and demonstrate its effectiveness in vivo using selected antibodies against anthrax proteins. The ideal protein carriers have to be not only non-toxic and non-immunogenic. The key for this prototype stage is to demonstrate the delivery of nanoencapsulated proteins against biological agents under in vivo conditions. Encapsulation of anthrax specific antibodies will be used with these nanocapsules. Prototype demonstration will be the encapsulation of anthrax antibodies with these particles and to be able to deliver them effectively in an animal model.

PHASE III DUAL USE APPLICATIONS: Large scale production of relevant protein delivery formulations for FDA approval. This platform technology can be used for both military (i.e. chem/bio agent countermeasures) and civilian (i.e., first responders) applications.

REFERENCES:
Protein Delivery, Physical Systems, Edited by Lynda M. Sanders and R. Wayne Hendren.
Chapter 6: Poly(ethylene-glycol) coated Nanospheres: Potential Carriers for
A04-193  TITLE: Simulation-Based Open Surgery Training System (SOSTS)

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: To develop and demonstrate a personal computer (PC) based Simulation of Open Surgery Training System (SOSTS) developmental platform to obtain surgical metrics (of devices, instruments and their use in procedures; of surgical technique) and to develop and evaluate new open surgical procedures and advanced medical devices. The ultimate goal is to improve training so surgeons can obtain and maintain proficiency in the performance of open surgical procedures. This is particularly relevant in trauma surgery and surgery in austere environments where open surgical technique is still regularly employed.

DESCRIPTION: Over the past four years, the U.S. Army’s Telemedicine and Advanced Technology Research Center (TATRC) has developed a research portfolio in Medical Modeling and Simulation (MM&S). As one of several funding sources, TATRC has authored SBIR and STTR topics seeking creative, innovative solutions to improve the training of health care providers “from the foxhole to the operating room and beyond”. This has potential to improve treatment and reduce surgical errors nationwide. Research has fallen into four categories of simulation: (1) PC-based interactive multimedia, (2) digitally enhanced mannequins that are stand-alone or integrated with other systems, (3) virtual workbench (part-task) trainers, and (4) total immersion virtual reality (TIVR). In seeking to support the development of enabling technologies for TIVR, research is being done in many areas, e.g., real-time in vivo tissue properties measurement, tissue-tool interactions, graphics and visualization, learning systems, metrics development and learning transfer assessment, open architecture strategies.

While tactile (haptic) feedback devices are desirable to “feel” tissue-tool interactions in minimally invasive (or minimal access) surgery, also desirable may be a system that simulates the “look & feel” of open surgical procedures. On the other hand, several reports and anecdotal evidence suggest that this tactile component might not be required for successful virtual reality training.

We seek creative and innovative solutions to surgical training that are not as reliant on high fidelity haptics feedback. We also seek to identify and to quantify methods and open surgical procedures relevant to surgical performance. Many surgeons use robotic devices to assist surgery, but some devices provide little or no tactile feedback. Because image visualization is superior, surgeons compensate for the lack of “feel”. The same holds for endoscopic surgeries where in some cases surgeons believe that students might develop better technique by not relying on tactile sensation, e.g., arthroscopic knee surgery, where touching the cartilage during navigation of tools can damage the tissues. If true when using a robotics or endoscopic device during an actual procedure, perhaps this may be at least partially true for a simulated procedure.

Traditional techniques for teaching trauma procedures have depended on both the availability of trauma patients and proctors with developed -- and retained -- skills to teach trauma procedures. Other approaches include practice on animals, although animal models of injury often do not reflect human trauma and raise ethical and economic issues related to procuring and maintaining animals for training. Also, practice limited to animals and humans limits the opportunity for trainees -- even trainers -- to repeat and rehearse parts of the procedure that may prove challenging.

Progress is evident in 3D visualization via both monitors and head-mounted displays. Progress in sensored gloves and/or hand tracking has been made, and creative innovative virtual environments integrating gloves and viewing devices, e.g., various types of glasses, Head Mounted Display, may allow a surgeon trainee to be partially immersed in a simulated environment. On the other hand, open surgery has proven to have a number of hurdles to include realism of tissues, integrating standard surgical instruments and their behavior in the virtual environment,
generating realistic tissue deformity and behavior, integrating the learner’s hands with the virtual environment. Though several groups have reported progress in some of these areas, it is clear that significant challenges remain. Our goal is to begin by calling for an open surgical simulation platform (preferably of open architecture to enable collaboration/interoperability) that will at the very least allow the rendering and use of virtual versions of actual instruments used in trauma surgery. The successful project would also develop a “toolbox” of digitized surgical instruments (utilizing techniques such as laser scanning) that could be developed, evaluated and refined in the open surgery simulator. A final goal would be to enable novel surgical instruments to be “scanned” and “virtualized” or entered into the simulator before they reach physical prototype stage and then evaluated.

PHASE I: Develop a concept plan for a Simulation of Open Surgery Training System (SOSTS). Concept plan should discuss the planned application architecture, image rendering (including lighting, tissues, fluids), tissue deformation and collision of instruments with tissues relevant to an open surgical simulator. Plan should discuss “digitization” of surgical instruments, e.g. method of digitization, format, rendering methods, etc. The concept should be broad enough so open-handed surgery procedures can be performed…

a. without tactile feedback,
b. without human, animal, or cadaver tissue,
c. either based on embedded metrics for comparison of outcomes or by obtaining or deriving new surgical metrics by using SOSTS,
d. with realistic appearance of tissue deformation in response to manipulation of tissue,
e. with at least a virtual reality (VR) interface (NOTE: multiple interfaces are acceptable, e.g., VR mouse, haptics device.
f. with some type of 3D visualization system,
g. based on instructional design and educational content appropriate to the procedure.

PHASE II: Develop and demonstrate a functional prototype of a full performance SOSTS with which a user can simulate the performance of an open surgery of simple to moderate complexity, e.g. splenectomy after trauma.

PHASE III DUAL USE APPLICATIONS: The SOSTS is desired for application to military and civilian medical training and has the potential to become the foundation for surgical training in the future. The development and commercialization of this technology could potentially provide surgeons with more frequent and higher quality training and lead to improved diagnosis, treatment planning, and procedure rehearsal. This has potential for the Department of Defense (DoD) and the nation to reduce surgical errors, improve patient safety, reduce cost, and improve access to care in fixed medical treatment facilities and improve medical educational training programs. This technology can also allow the assessment of novel surgical instruments and techniques “in silico” in turn limiting use of animals and reducing development costs.

REFERENCES:
6)

KEYWORDS: medical modeling and simulation, surgical training, virtual reality, haptics gloves, force feedback, visualization, 3D graphics, sensors, head mounted displays

A04-194 TITLE: Development of High Throughput Bioassays to Identify Correlates of Protective Immunity Against Malaria

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: We seek the development of innovative high throughput bioassays to profile cellular or humoral protective immunity against malaria and to identify correlates of protection.

DESCRIPTION: Over the last years, the genome sequencing projects for a variety of pathogens have been completed. This wealth of genomics information can be used for vaccine development. In contrast to conventional vaccine development strategies, a genomics-based vaccine discovery allows the evaluation of all genes, independent of their abundance and immunogenicity during infection and without the need to grow the pathogen in vitro. Each single gene of the entire genome is a potential vaccine candidate and the efficacy of its recombinant form can be tested. But genomics-based vaccine screening assays require host correlates predictive for protection.

The Department of Defense (DoD) has a great interest in vaccines against malaria and other infectious diseases. Malaria occurs naturally in most tropical and subtropical countries. Infants, young children, pregnant women, travelers and military personnel are mostly non-immune to malaria infection in these endemic areas. The likelihood that military personnel, whether involved in major conflicts or in peacekeeping missions, could suffer disease and non-battle injury (DNBI) from malaria is quite large. Historically, malaria has caused a greater loss of manpower than enemy fire in all conflicts occurring in tropical regions during the past century. The DoD has a special interest in P. falciparum, the deadliest of all the malaria pathogens. To date there is no licensed malaria vaccine and the parasite is developing resistance against most, if not all, current anti-malarial drugs. The Plasmodium falciparum genome project (Sanger, TIGR/NMRC, Stanford) has resulted in the identification of over 5,200 genes. All of them are potential vaccine candidates, but host correlates of protection are missing to evaluate these candidates.

Correlates of protective immunity against malaria are desirable for several reasons: 1) to be able to evaluate potential vaccine candidates and to identify or prioritize protective antigens derived from the plasmodium genomes, 2) to demonstrate the immunogenicity of a vaccine candidate and its potential efficacy, and permitting optimization of the dose, vehicle, adjuvant, and schedule of immunization during clinical trials, and 3) to demonstrate that anti-malarial vaccinations are effective in deployed troops.

Models of protective immunity of malaria can be used to identify correlates of protection. The most powerful models of protective immunity of malaria are those in humans: immunization with radiation attenuated sporozoites or naturally acquired immunity. The protective immunity in the irradiated sporozoite model is elicited by exposure to the whole parasite. Gamma-irradiated Plasmodium sporozoites are able to invade the host hepatocyte and undergo limited development, but cannot mature into blood-stage parasites. Immunization of mice or humans with gamma-irradiated sporozoites confers sterile protection against sporozoite challenge in most recipients. Protective immunity can be determined by profiling the immune responses of protected versus non-protected human volunteers, or rodents immunized with radiation-attenuated Plasmodium ssp. sporozoites.
To date, no high throughput assay, which reliably predicts protective immunity against malaria, is available. High throughput bioassays should cover humoral, adaptive and/or innate immunity and can be based on genomics, proteomics or other technologies. The format of the bioassay should be in such a way, that host correlates of protection could easily be extracted and used to screen vaccine candidates later on. The proposal should contain the bioassay itself and provide solutions how to identify correlates of protection with available or customized software. Priority will be given to the evaluation of assays which can be adapted for rapid and/or large-scale profiling and which require small amounts of starting specimens.

PHASE I: Demonstrating the proof-of-principle, that the bioassay is high throughput and is able to profile immunological responses.

PHASE II: Demonstrating that the assay is able to profile protective immunity in the radiation-attenuated sporozoite model and can identify correlates of protection.

PHASE III DUAL USE APPLICATIONS: This bioassay could be used in a broad range of military and civilian applications where vaccine development against infectious diseases and the identification of correlates of protective immunity is warranted.

REFERENCES:

KEYWORDS: genomics, functional genomics, proteomics, high throughput bioassays, protective immunity, correlates of protection, biomarker, in vitro surrogates, malaria, Plasmodium falciparum, Plasmodium yoelii

A04-195 TITLE: Ballistic Protection for Army Aviation Helmets

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Design and construct a modular, removable, ballistic protective covering for the HGU-56/P flight helmet capable of protecting Army aircrew from the threat of small arms fire and shrapnel, thereby reducing the risk of penetrating brain injury (in addition to protection against blunt head impact already provided by aircrew helmets). Injury protective system will take into account known mechanisms of penetrating cerebral injury pathophysiology, and will be evaluated by the Surgeon General using conventional injury assessment techniques to assess injury prevention/reduction potential.

DESCRIPTION: In modern Army helicopters, aviators are protected from ballistic threats by armored seats, armored panels, and man-mounted personal armor. These interventions protect the upper and lower torso from penetrating injury, but leave the head exposed and unprotected. Aviators are equipped with flight helmets, but these helmets are designed to protect against relatively low speed (when compared to ballistic threats) blunt impacts incurred during survivable helicopter crashes. The ballistic protection requirements for these helmets is limited to the polycarbonate visor, which must stop a 17-grain .22 caliber fragment simulating projectile moving at 550 feet per second (MIL-V-43511C, 1990). Protection from penetrating brain injury is urgently needed by aviation warfighters currently at risk in Operation Iraqi Freedom.

Previous attempts have been made to integrate ballistic protection into the shell of aircrew helmets. In the 1960s, the Army fielded an anti-fragmentation helmet, the AFH-1. This helmet incorporated nine plies of ballistic nylon
fabric cast in a resin matrix. The AFH-1 provided protection against ballistic fragments (Latnick, 1967), but aviators considered it too heavy to be worn for long duration missions, and it was eventually abandoned.

Materials technology has progressed greatly since the 1960s. It is likely that current, state-of-the-art materials could be used to provide ballistic protection for the current generation of Army aviation helmets without an intolerable increase in head-supported weight. Such materials must be assessed for their ability to a) reduce or prevent primary penetrating craniocerebral trauma, b) cause secondary injury (e.g., undesirable behind armor effects), and c) potentially degrade blunt injury protection afforded by the aviation crash helmet.

PHASE I: Identification of novel, lightweight ballistic materials for possible use in design of a modular, removable, ballistic aircrew helmet covering. Perform a trade study to identify the material (or combination of materials) that will optimize ballistic protection while minimizing additional head-supported weight and helmet external profile (due to the addition of the ballistic covering), while preserving the helmet’s inherent blunt impact protection. Conceptual design of a prototype modular, removable, ballistic covering for the HGU-56/P flight helmet. Use of the ballistic covering should not require any significant modification of the existing HGU-56/P flight helmet. The ballistic covering should: (1) accommodate all sizes of HGU-56/P, (2) be easily donned and doffed while in flight, and (3) be compatible with existing helmet-mounted equipment (HME) (e.g., night vision devices, chemical/biological protective masks, maxillary facial shields, etc.), and magnetic head tracking systems.

PHASE II: In the initial portion of Phase II, the contractor will construct prototypes of the modular, removable, ballistic aircrew helmet covering based on the Phase I conceptual design. Probable technical challenges will include the development of manufacturing (e.g., material lay-up and bonding procedures) and machining techniques required to construct the ballistic covering, and designing a means of attaching the ballistic covering to the HGU-56/P helmet that does not require significant modification to the helmet and does not interfere with existing HME. In coordination with Army Medical Department experts monitoring the SBIR effort, the contractor will demonstrate the ballistic covering’s effectiveness at mitigating ballistic threats, and demonstrate the effect of the ballistic covering on the weight, center of mass (CM), and blunt impact protection of the HGU-56/P flight helmet. At the end of Phase II, 12 prototype ballistic coverings (three coverings for the four HGU-56/P helmet shell sizes), as well as all data collected during contractor weight, CM, blunt impact protection, and ballistic protection testing, will be provided to USAARL for operational user and performance evaluations. Helmets will be assessed for their ability to reduce the health hazard of penetrating head trauma, and their impact on other health-related variables (weight, CM, etc).

PHASE III DUAL USE APPLICATIONS: A modular, lightweight device that will improve the ballistic protection of crash helmets, and reduce traumatic brain injury, will be useful in many military and commercial venues. This solicitation is targeted at providing ballistic protection to Army aviators wearing the HGU-56/P flight helmet. However, the US Air Force, Navy, and Coast Guard are transitioning to the HGU-56/P flight helmet. These services would likely have a similar need for a modular, lightweight ballistic helmet covering. In addition, the materials and construction techniques developed during this SBIR could be used to create similar devices for use by civilian, public service and paramilitary organizations (e.g., state and municipal law enforcement agencies, US Customs Service, US Drug Enforcement Agency, US Immigration and Naturalization Service, etc.). Motorcycle patrol officers and helicopter aircrew employed by these agencies require protection from blunt impact hazards (e.g., crashes), as well as ballistic threats (e.g., bullets, improvised explosive devices, etc.).

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Improved warfighter survivability during aviation operations. Reduce cost of death and medical disability due to penetrating head injury with consequent brain damage.

REFERENCES:

KEYWORDS: Ballistic, blunt impact, aircrew helmet, aviation, protection, head injury
A04-196 TITLE: A Homologous Non-Human Primate Model System for Producing and Testing Recombinant Human Compatible Serum Butyrylcholinesterase

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: The objective of this program is to develop a homologous non-human primate model for producing a recombinant butyrylcholinesterase (BChE) that is compatible with serum (Ma BChE) for use as a pharmaceutical and bioscavenger to afford protection against nerve agent and pesticide poisoning. A comparison of the pharmacokinetic properties of recombinant macaque BChE with those of native plasma-derived Ma BChE in macaques will aid the development of recombinant enzyme that possesses circulatory properties similar to those of plasma-derived Ma BChE. The development of this homologous system will facilitate the production of recombinant human (Hu) BChE that is compatible with plasma-derived Hu BChE and is suitable for human use.

DESCRIPTION: Exogenous administration of plasma-derived cholinesterases (ChEs) such as acetylcholinesterase (AChE) and BChE has been successfully used as a safe and efficacious prophylactic treatment to prevent poisoning by organophosphorus (OP) compounds in the form of nerve agents and pesticides (1). Based on availability, broad spectrum efficacy, stability and safety, homologous Hu BChE represents to date the best drug candidate for a prophylactic human treatment against OP toxicity (2). Large quantities of Hu BChE displaying a high stability upon long-term storage are required for defining its therapeutic capacity in vivo, its pharmaceutical properties, and for clinical trials.

The military relevance for developing a prophylactic treatment in the form of a bioscavenger that can protect soldiers from the toxicity of chemical nerve agents is mandated in DTO D (Title: Nerve Agent Biological Scavenger). As stated in the program plan, the objective is to develop plasma-derived Hu BChE as a biological scavenger nerve agent pretreatment that can detoxify nerve agents at a sufficient rate to protect the warfighter from exposure of up to 5XLD50 of nerve agents without physiological or psychological side effects.

Outdated and otherwise unused human plasma and other blood by-products such as Cohn Fraction IV-4 (depleted of other blood products but not Hu BChE) are a ready and large source of Hu BChE. In addition, the bioscavenger can be produced by recombinant DNA technology and expressed in tissue culture or transgenic animals. However, the resulting purified or recombinant Hu BChE must display the same enzyme activity, mean residence time in circulation (MRT), and lack of immunogenicity, as the native human product. Studies in our laboratory have indicated that Hu BChE produced by recombinant DNA technology contains glycans that display a remarkable heterogeneity in size and lack mature glycans that represent the major constituents of plasma-derived enzymes (3,4). In addition, recombinant Hu BChE is primarily expressed as a mixture of monomers and dimers, and only 10-30 % tetramers (5), compared to the native plasma derived enzyme that is >95% tetrameric in form (4). The net result is that the MRT of a recombinant ChE is one-tenth of the corresponding plasma-derived enzyme (4). Therefore, recombinant Hu BChE produced by currently existing technology is unsuitable as a bioscavenger and further studies are needed to make it compatible with the native enzyme.

A major problem for evaluating and comparing the in vivo properties of recombinant Hu BChE with native plasma-derived enzyme is that these studies will be conducted in rodents or non-human primates and results will be extrapolated to humans. A heterologous enzyme injection of Hu BChE in animals has a much shorter MRT and always results in an immunological response (6). Therefore, a more realistic approach is to conduct these studies in a homologous system, which will mimic a homologous Hu BChE injection in humans. The development of a homologous non-human primate system will provide guidelines for the production of recombinant Hu BChE suitable for human use.

PHASE I: Phase I research will consist of obtaining recombinant and plasma-derived forms of Ma BChE from any non-human primate source such as rhesus or cynomolgus or african green monkeys. This will be achieved by obtaining a cDNA clone of Ma BChE and introducing it into a mammalian expression system, to express sufficient quantities of recombinant enzyme. The plasma-derived enzyme will be obtained using a commercial source of
plasma from the same species of non-human primate from which the cDNA clones will be obtained. Both forms of enzymes will be purified using published procedures (6) and their pharmacokinetics will be compared in mice.

PHASE II: Phase II research will consist of defining and developing a process that will produce a recombinant form of macaque BChE with chemical and functional characteristics similar to those of the plasma-derived form. The recombinant enzyme will be characterized with regard to glycan structures and subunit assembly to ensure that these characteristics are similar to the plasma-derived form prior to evaluation of in vivo properties in macaques. The pharmacokinetics of both forms of enzyme will be evaluated in macaques and the recombinant form of the enzyme should have similar pharmacokinetics as the plasma-derived form. A second enzyme injection will be administered four weeks later to evaluate pharmacokinetics and immunological consequences of repeated enzyme administration. The methodology developed for producing the most stable form of recombinant Ma BChE in Phase II, will be adopted for producing recombinant Hu BChE in Phase III (using cGMP procedures according to FDA guidelines for parenteral injection). It will also involve performing or participating in pre-clinical testing of the Hu BChE by determining circulatory half-life in humans. Participation in the dual civilian use (e.g., as a cocaine detoxifying agent as described in dual use applications or in the treatment of succinylcholine-induced apnea /pesticide overdose) would require additional clinical testing.

PHASE III DUAL USE APPLICATIONS: (A) Hu BChE will provide an immediate pretreatment agent for soldiers who are entering an area where OP nerve agents might be used for an extended period with no weight penalties, behavioral alterations, or performance reductions (1, 2). The dose administered would determine the level of protection, but at the very least, a 200 mg dose to protect against 2XLD50 of soman could be injected. (B) The same process and advantages would exist for any first responders (civilians) reacting to terrorist nerve gas release/attack or pesticide overexposure or succinylcholine-induced apnea (7). Injection of the bioscavenger enzyme would occur on the way to the incident and provide immediate protection without delay. (C) Hu BChE will also provide treatment for cocaine overdose since the enzyme rapidly hydrolyzes certain non-choline esters including this drug of abuse (8-10). In the United States alone, approximately 165,000 cocaine intoxicated individuals per year visit the emergency room (11). Exogenously enhanced plasma ChE activity was protective against cocaine toxicity in animals. Also, BChE activity is present in the human placenta (12), and alterations in its level may explain why only a few cocaine-exposed fetuses suffer cocaine-related complications when most do not.

REFERENCES:


KEYWORDS: bioscavenger, human butyrylcholinesterase, recombinant DNA technology, glycols, subunit assembly, organophosphorus chemical warfare agents, pesticides, cocaine

A04-197 TITLE: Smart Devices/Instruments For a Sophisticated OR Environment

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: Develop and design a new generation of “smart devices/instruments” that incorporate the latest ergonomic and sensory augmentation principles that will restore tactile feedback to the minimally invasive surgeon operating in the Operating Room (OR) of the Future. The OR of the Future will emphasize the utility of minimally invasive tools and techniques to improve overall clinical outcomes and reduce cost.

DESCRIPTION: When new technology is introduced, claims of improved efficiency are often made. Yet, as one looks at today's OR, one sees a high density of complex instruments, often arrayed or utilized in an ergonomically and/or sensorially suboptimal or unsafe fashion. Minimally invasive surgery (including robotic surgery) has grown considerably in capability and scope. However, with increased use and resultant reports in the medical literature and news media, important weaknesses have been identified. The weaknesses include poor tactile feedback, inability to fully manipulate instruments inside patient’s body, impaired vision/field of view/depth perception, a lack of development of semi-autonomous surgical tasks such as retraction or certain movements involved with suturing, and a need for multifunctional instruments to limit instrument changes requiring removal of devices from the body. Though some solutions have begun to be addressed in industrial and academic research settings, it is important to move these advances to where they can be further developed and refined through use by surgeons in bench and eventually clinical settings. Also, it is important to continue to develop novel instruments and capabilities-which can be done quickly and effectively by employing development teams of expert surgeons, human factors experts, and engineers. Some of these solutions involve the novel utilization of force and strain gauges on surgical instruments, tactile feedback sensors at instrument tips, and novel articulation systems to allow increased degrees of freedom of movement without reducing instrument functionality/safety. The research focusing on such advanced devices needs to be guided by several key considerations. They include first and foremost improving patient safety and clinical outcomes (in part by recognizing and reducing errors); cost effectiveness; interoperability and standardization of interfaces, plugs, architecture; coherent integration of various components of devices, OR platform, Information Technology; and optimizing ergonomics and human factors issues at every level of design.

PHASE I: Conduct a literature review and gather baseline data focused on past and current work being done in fields related to ergonomic and sensory augmentation principles in developing minimally invasive surgical tools. Evaluating “Advanced device” development in non-healthcare industries may be helpful and time saving. These
baseline data must be adequately collected under the auspices of a multidisciplinary group comprised of clinicians, engineers (i.e., Biomedical, Mechanical, Electrical, Human Factors and Computer) and programmers. Provide a detailed illustrative report that identifies safer and more effective ergonomic principles, to include sensory augmentation when relevant, in developing minimally invasive tools. Using this report, describe your approach to addressing the task outlined in Phase II.

PHASE II: Design, develop and demonstrate a functional prototype of a ‘smart laproscopic device/instrument’ utilizing the following advancements:
- Tactile feedback component – force feedback research undertaken by robotics labs/programs/companies should be explored. (This is the realm of tactile sensory augmentation.)
- Degrees of Movement Component – focused on the development of more flexible, lighter, less expensive and mobile, robotically assisted (hand held) devices. (This is the realm of ergonomics.)
- “Smart Sensor” Component - focused on the harnessing of existing technology and imaging modalities such as ultrasound and Infra Red and exploration of new technologies to equip end effectors to provide intraoperative guidance and error avoidance. MEMS, Ultra-Wideband Radar and new membrane technologies could provide potential applications to this problem. (This realm would combine imaging (vision) with force-sensing and texture reproduction in the realm of sensory augmentation)

PHASE III DUAL USE APPLICATIONS: The ultimate goal of this research will be to provide increased levels of knowledge and understanding through improved sensory fidelity of minimally invasive devices/instruments to clinicians in military and civilian surgical settings with a new generation of “smart devices/instruments” that incorporate modern ergonomic principles that will restore tactile feedback to the minimally invasive surgeon operating in the OR of the Future. For example: a penetrating injury to the abdomen requires the surgeon to “run the bowel” using the senses of touch and vision to identify perforations/injury. Present endoscopic technique relies on visual inspection alone (thus this procedure is performed in an open manner by conservative surgeons). Technologies resultant from this topic could allow tactile feedback through the instruments themselves or via analogues such as sound or skin/tongue tactile situational awareness devices. This would allow military and civilian surgeons to utilize minimally invasive technologies to safely perform exploratory abdominal surgery.

REFERENCES:
HIGH-THROUGHPUT PROTEOMICS STRATEGY FOR DETECTION AND IDENTIFICATION OF BIOMARKERS OF MALARIA EXPOSURE

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: The overall goal is to develop and validate a novel, high-throughput method of detecting and identifying biomarkers of malaria exposure by capitalizing on recent advances in proteomics, genomics, or other technologies.

DESCRIPTION: U.S. military personnel deployed in tropical areas remain at risk for the development of malaria, and the increase in drug-resistant parasites have made the development of new malaria drugs essential. For instance, of the 225 Marines and Navy forces who went ashore to assist West African peacekeepers in Liberia, 51 showed symptoms of malaria. Tafenoquine, an 8-aminoquinoline antimalarial currently in development, is in Phase III prophylaxis trials. A surrogate marker of exposure would help to definitively determine exposure rates and therefore how well its antimalarial prevention is working. In addition, it would help to establish proof of efficacy without use of a placebo group. Although a placebo group is typically used in Phase II and III trials, giving a placebo to non-immune subjects at high risk of contracting a life-threatening disease is quite risky and possibly unethical.

The current options for assessment of efficacy (semi-immune subjects or non-immune subjects without a placebo arm) suffer from a number of disadvantages. Semi-immune subjects most likely overestimate protective efficacy and therefore a drug may not work in troops despite being efficacious in the trials. The other option is to study a representative population without a placebo arm. For example, a 6-month trial in 600 Australian soldiers was just completed in East Timor. The results of this trial are not definitive: we do not know how effective tafenoquine or melfoquine was in preventing malaria because we don’t know if or how much the soldiers were exposed to Plasmodium falciparum. Identification of a validated marker of exposure would help to eliminate this ambiguity and would allow us to determine from their pre- and post-deployment sera if these soldiers were exposed.

In an effort to improve the speed and sensitivity of diagnosis in infectious disease, biomarker detection using molecular methods has been used increasingly over the last decade. Biomarkers are measurable phenotypic parameters (or molecular signatures) that characterize an organism’s state of health or disease, and their identification and detection are valuable tools for monitoring exposure to a particular disease or pathogen. For instance, PCR has been used successfully in commercial test kits to detect a variety of organisms including the Mycobacteria, Chlamydia, and Mycoplasma. Gene expression profiling and proteomic profiling have been used extensively in biomarker discovery (2-6). Proteomic profiling, however, has advantages over reverse transcription-polymerase chain reaction (RT-PCR) in that it is more rapid, easily adaptable to high throughput, and provides information about the product of transcription, i.e., protein. Proteomics also has the opportunity to be more sensitive than techniques such as ELISA, which are used in malaria to detect anti-circumsporozoite antibodies with limited success.

In view of this, commercial interest is being sought in the development of a new high-throughput strategy for the identification and screening of biomarkers of malaria exposure. The resulting platform should take advantage of advances in molecular methods such as proteomics, genomics, or other technologies to develop a sensitive, specific, and high-throughput method, in either a lab-based or deployable format.

PHASE I: The goal of this phase is to conduct a proof-of-concept study that can demonstrate the ability to detect exposure to a relevant pathogen.

PHASE II: This phase will involve the development of a high-throughput method for the detection of a biomarker (or biomarkers) of malaria exposure. Once markers have been identified, the method should be validated by using...
the discovered pattern to classify independent sets of masked serum (or other biological fluid) samples. Successful results will establish that the method is sensitive enough (sensitivity > 95%; specificity > 95%) to detect malaria-infected samples from a sample pool of malaria-infected, non-infected, and infected with other diseases with similar presentations.

PHASE III DUAL USE APPLICATIONS: The development of a technology platform to detect malaria biomarkers could be used by civilian as well as military researchers and clinicians in diagnosis and clinical drug trials. In addition, we expect that the information generated (i.e., the identity of the biomarkers discovered) would be used by the research community to advance our knowledge of the cellular and molecular basis of malaria disease progression. Furthermore, this technology could be extended and would be expected to advance efforts in drug and vaccine development as well as to aid in diagnosis and discovery of biomarkers for other infectious diseases such as dengue fever, Ebola virus, typhoid fever, and others.

REFERENCES:

KEYWORDS: malaria, exposure, biomarkers, proteomics, genomics, molecular methods, mass spectrometry, drug efficacy, prophylactic, tafenoquine, 8-aminoquinoline, placebo, clinical trials

A04-199 TITLE: An Active Noise Reduction Communication Earplug for Helicopter Crew

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: To develop and test an active noise reduction (ANR) earphone system, to be worn inside the ear canal, to be used by helicopter crew for speech communication and hearing protection. The earplug-like system, in combination with an HGU-56 helmet, should be able to provide a combined active and passive insertion loss or ‘effective attenuation’ (1) of at least 40 dB for all frequencies, produce a clear speech quality, and be compatible with U.S. Army safety requirements, particularly with respect to potential injuries caused by side impacts (2).

DESCRIPTION: Active noise reduction (ANR) is a technique of picking up noise signals with a microphone in one part of a system and, after some signal processing, reproducing it through a loudspeaker in the proper amplitude and phase at another location in the system so that the electronic signal cancels the already present acoustic noise signal.

Active noise reduction is a very lively field today, and is a very significant component in our worldwide effort towards noise and vibration control. It is applied, among others, to architectural structures, power plants, vehicles, musical instruments and communication systems. An international symposium under the name ACTIVE is held every few years to review progress and success of the many applications that have been developed using the ANR technique. In this research proposal we will concentrate on ANR techniques applied to communication headsets.
Presently there are many headphone-based ANR systems on the market, designed for pilots as well as passengers. The best performing systems typically provide a rather flat, frequency-independent attenuation of about 20 dB. Below 200 Hz this attenuation is almost entirely caused by active electronics, above 600 Hz by the passive reflection and absorption of the earmuff, and between 200 and 600 Hz by both mechanisms. Several physical performance reviews of such systems have been published in the recent past (3,4,5,7). Perceptual performance on ANR headsets data are less plentiful, but can to a large extent be accurately predicted from the physical performance measures and the extensive literature on psychoacoustics (for a review, see ref. 8). Some perceptual performance data have been published on comparative speech intelligibility with and without the use of ANR, measured by the STI (speech transmission index) method, by CVC recognition tests, and by speech reception threshold measurements (9).

Just about all ANR available today use a signal-feedback principle, and therefore typically have a reference microphone mounted inside an earcup. A safety test for use in helicopters, however, showed this design type to be structurally deficient because of its bulkiness and rigidity, posing a danger to the wearer during lateral impacts against the helmet (2). On the other hand, deep-seated earplug types of ANR devices, for instance the ones developed for use in very high-noise (150 dB) environments on carrier flight decks, have an unavoidable amount of wearing discomfort as a price to pay for a large amount of passive attenuation. It is doubtful that such designs will ever find acceptance for general use in helicopters, where noise levels seldomly exceed 120 dB. As a result, the current communication technology for helicopter crews consists of the communication earplug (CEP), a simple passive-insulation insert earphone worn in combination with soft helmet-mounted earmuffs (5), without application of any active noise reduction.

Given today’s advances in hearing aid technology, it seems quite feasible to develop a small microphone-telephone system with sufficient signal processing capability to achieve useful ANR levels in a device that can be worn entirely inside the ear canal. Together with the conventional helmet-earmuff combination, noise reduction levels could be reached that are much larger than what is presently achieved with purely passive means. The feasibility of such an ANR earplug is supported by recent research advances in earplug design (10,11), feed-forward technology (12), fast and efficient signal processing algorithms (13), and by the emergence of a few promising and potentially adaptable industrial prototypes (6). A suitable ANR earplug for safe and effective use in helicopters, however, is by no means an ‘off-the-shelf’ item. Considerable applied (see risk factors 1 and 2 below) and fundamental (risk factor 4) research is necessary to develop a suitable prototype.

Advantages of the earplug-design, in comparison with headphone-designs, are:
1. There will be minimal added risk of head damage during a crash or other violent side impact.
2. The small dimensions of the device will allow effective cancellation in noise bands of higher frequencies.
3. A feed-forward design from a microphone outside to a telephone inside the plug allows a total separation of noise signals (to be cancelled) and speech signals (to be transmitted)

Risk factors in the design are reflected in the following questions:
1. Can a sufficient acoustic seal be achieved without custom fitting, to prevent unwanted acoustic feedback?
2. At what point will bone-conducted noise begin to dominate the hearing process, so that additional acoustic ANR is no longer effective?
3. At what point will the interference of noise in the speaker-microphone link of the communication chain become so dominant that further reduction of noise in the hearing process does no longer improve speech intelligibility?
4. Is there a lower limit on noise reduction, beyond which a pilot’s inability to perceive the functional sound of the helicopter might pose a safety hazard in the case of mechanical failure?

Payoff:
If successful, the ANR communication earplug will further reduce the background noise experienced by helicopter crewmembers. This is not only important for long-term hearing conservation, but also for communication intelligibility, especially for crewmembers with acquired noise-induced hearing losses. Hearing-impaired persons often have more difficulty understanding speech in noisy environments than normal hearing persons. Finally, if 3D sound displays are to be used as part of multi-sensory communication systems in helicopters, such displays may be effective only if background noise levels in the ears of the listener are lower than they presently are.
PHASE I: Phase I of the project will consist of developing the basic ANR and signal processing system that meets the specifications of noise reduction, speech signal transmission, and helicopter aviation safety requirements. Such a development is envisioned to be a combination of sealed-earplug insert-phone system design and feed-forward ANR electronics, and could in physical appearance and user comfort resemble the existing and certified Communication Earplug (CEP). The end product of this phase is envisioned to be a working laboratory model of an ANR earplug that could, in principle, meet all the intended specifications shown below (under Phase II).

Phase II: Phase II consists of development and testing of a working ANR earplug prototype that meets requirements for regular use by aircrew in helicopter aviation. Technical specifications to be met, as currently envisioned, are:
(a) Units should have an earplug-type design, should fit inside the ear canal without any parts protruding, and should feel comfortable to the user at all time;
(b) Units should have a passive attenuation (insertion loss) of at least 25 dB at frequencies below 500 Hz, and at least 50 dB above 3000 Hz, according to the ANSI S12.6 (REAT) standard;
(c) Units should have an additional active attenuation of at least 20 dB for frequencies below 1000 Hz;
(d) The electronics circuitry should be stable for any external noise exposure up to 120 dB(C)

Airworthiness (ACE) testing, which is a prerequisite for the next phase, will be performed through USAARL with separate funding, and is not part of an SBIR contract. The end product of this phase is envisioned to be a fully functioning prototype that meets all requirements of technical performance, safety, airworthiness and comfort for general use in helicopters.

PHASE III: Phase III consists of production and commercialization of the ANR earplug for use within the Armed Forces, wherever feasible. For occasional performance and safety tests that may have to be performed on possible extensions, additions, or modifications of the basic product, the USAARL staff, its ACE testing lab, its UH-60 simulator, and its UH-60 aircraft, should remain available as a resource at the company's expense. Other possible applications of the design, e.g. to military and civil fixed-wing aircraft or as a consumer product accessory to a Walkman, could also be explored during this phase.

REFERENCES:
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7) Carlson, J., Active noise reduction (ANR) headsets for air mobility command (AMC) aircrews. Air Mobility Warfare Center, Ft. Dix, Nov. 2001
OBJECTIVE: Design and demonstrate a low power bi-directional data communication and antenna system utilizing the volume conduction properties of biological tissue for data communication between the inside and outside of the human body.

DESCRIPTION: Although computers and Internet connections are becoming accessible essentially from anywhere in the world, there exists a gap of information connection between the inside and the outside of the human body. The ultimate objective of this topic is to eliminate this gap and establish a wireless data communication channel in order to: 1) perform invasive physiological monitoring with biological sensors intended to provide data for assessing health status of soldiers or performing computer aided remote triage of combat casualties, 2) release computer selected protective drugs internally when a soldier is wounded or attacked by chemical/biological agents, 3) increase the awareness of hostile environments by channeling sensor/computer generated signals directly to the human nervous system (brain-computer interface), and 4) enhance human performance or vigilance at critical moments during a combat mission or rescue process by internal stimulation. For some time the military medical services have focused research on noninvasive physiological monitoring sensors as a means of obtaining data for remote triage of combat casualties and for soldier health and performance monitoring. It has become increasingly evident that noninvasive sensors may not be able to collect all the data parameters crucial to remote triage or soldier health status monitoring and prediction. Therefore invasive/internal physiological sensors may be needed. Likewise, emerging signal and control technologies even at the nanometer level may enable preventive or post injury treatment or therapy interventions to be performed internally by miniature robots upon electronic command by human medical providers or computers. A major problem to overcome with data transmission into and out of the body, before effective invasive physiological monitoring or autonomous interventions can be operationalized, is development of very small two-way antennae that will efficiently transmit data through body fluids with self-contained or self-generated long-lasting power sources. In data communication systems, information is passed from the transmitter to the receiver through certain physical variables, such as an acoustical wave in the case of ultrasound systems and an electromagnetic wave in the case of radio frequency (RF) systems. In a fluid-dominant conducting medium, such as the tissue in the human body, excessive attenuation and/or delay reduce the capacity, range, and speed of data communication. However, there exists a natural passageway of information. Body fluid conducts electrical current which, when intentionally manipulated, may carry information as desired. This conduction is called volume conduction. Electrostatic laws of physics state that a current source within a volume conductor results in an electrical potential distribution within and on the surface of the conductor. Utilizing this physical principle, a data communication system may be built. Feasibility has been discussed in the literature (Reference 1). Likewise the power required to operate internal sensors and transmitters precludes long term continuous operation. Theoretically the power electrical potential distribution created by the volume conductor could be used as the sole power source for the volume conductor data communication and antenna system.

PHASE I: Design a self-powered or low power bi-directional data communication and antenna system utilizing the volume conduction properties of biological tissue for data communication between the inside and outside of the human body and demonstrate proof of concept using a single internal sensor such as core temperature.

PHASE II: Develop a working prototype bi-directional invasive medical data communication and antenna system utilizing the volume conduction properties of biological tissue sufficient for communicating with invasive physiological monitoring sensors inside the human body. Conduct animal model demonstration of data communication sufficient for invasive physiological monitoring via an internal sensor such as core temperature. Demonstrate two-way communication with the sensor by sending instructions (e.g. off/on) and receiving data from the sensor.
PHASE III DUAL USE APPLICATIONS: Conduct initial human-use safety trials to demonstrate data communication sufficient for invasive physiological monitoring via internal sensors. Seek FDA approval to integrate, market, and use the technology for both the military and civilian applications such as: 1) perform invasive physiological monitoring with biological sensors intended to provide data for assessing health status of soldiers or civilian emergency responders or performing computer aided remote triage of combat casualties or civilian victims of acts of terrorism or natural disasters, 2) release computer selected protective drugs internally when a soldier or civilian emergency responder is wounded or attacked by chemical/biological agents, 3) increase the awareness of hostile environments by channeling sensor/computer generated signals directly to the human nervous system (brain-computer interface), 4) enhance human performance or vigilance at critical moments during a combat mission or rescue process by internal stimulation, and 5) transition and market this technology to non-emergency military and/or civilian programs requiring internal/invasive sensors, such as home monitoring.

REFERENCES:

KEYWORDS: invasive physiological monitoring; internal biomedical sensors; biomedical sensor communications; volume conduction antenna; medical monitoring; health surveillance; home health monitoring

A04-201 TITLE: Novel Routes of Drug Administration to Enhance Compliance in Soldiers

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Deputy for Acquisition and Advanced Development – USAMRMC

OBJECTIVE: The objective of the topic is to develop an approved transdermal device to prevent malaria and save lives by enhanced compliance.

DESCRIPTION: Malaria is a major infectious disease threat to U.S. forces deployed worldwide and can rapidly incapacitate large numbers of personnel. Our recent experience in Liberia exemplifies the problem. Of 290 troops who stepped ashore there, 80 developed malaria (28%), and 69 of the 147 who spent at least one night ashore acquired it (44%). Five of these marines required intensive care unit support. We are fortunate no lives were lost. Incomplete compliance with malaria prevention medication was determined to the cause of the problem.

Antimalarial prophylaxis has two common important limitations: non-compliance with medication and minor side effects (e.g. gastrointestinal intolerance). A weekly transdermal medication would substantially resolve these two
major drawbacks. Moreover, antimalarial drugs with inadequate oral efficacy, candidates with first pass/intestinal metabolism, or acid instability may achieve acceptable efficacy via this novel route (e.g. azithromycin).

Transdermal medications have been in clinical use for many years. Some of such products include the nitroglycerin, estradiol, clonidine, fentanyl, nicotine, scopolamine, and estradiol. Each year, the technology to deliver more challenging molecules is improved. As yet, no antibiotics or antiparasitics are available (or are being developed) for delivery by this unique route.

Antimalarial drugs have properties that make them good candidates for transdermal absorption – lipophilicity. Klayman and colleagues first showed that antimalarials could have transdermal activity with artemesinin derivatives in mice (6). Transdermal primaquine has been shown to have causal prophylactic activity in mice (7, 8). Both transdermal primaquine (5) and doxycycline (9) have sufficient flux across cadaver skin to predict that therapeutic plasma drug concentrations will be achievable in clinical use. Studies with transdermal erythromycin suggest that therapeutic concentrations should be achievable (3), suggesting that this route may also work for azithromycin.

Drugs are also commercially available and experimental hormones are administered via subcutaneous implant (1, 2, 4). It is possible that drugs of importance to US military could also be administered in this fashion.

It is generally accepted in the medical community that the less frequently a drug is dosed, the higher compliance is. The two most relevant references compare oral versus transdermal contraceptives in randomized controlled trials. The patch versus oral contraceptive efficacy was 94% vs 74% (p < 0.001) in the first trial and 88% vs 78% (p < 0.001) in the second (10, 11). For military purposes, monitoring of the presence or absence of a patch would be much simpler than monitoring of daily or weekly dosing of a medication.

PHASE I: Identify appropriate antimalarial drugs and innovative technologies for drug delivery. Perform initial assessment of pilot patches using standard pharmacological methodologies (e.g. transdermal flux, pharmacokinetics, animal efficacy) to select optimal delivery technology for specific antimalarial drug classes using currently available drugs. Examples of possible drugs for testing include primaquine, doxycycline, azithromycin, atovaquone-proguanil, methylene blue, desbutylhalofantrine, and artemisone.

PHASE II: Down select to lead candidates, perform proof of concept in clinical trials.

PHASE III DUAL USE APPLICATIONS: Perform clinical trials that will lead to approval of new FDA-approved malaria prevention product. A protective efficacy of 85% with a lower confidence interval of 70% is the minimum standard, with 95% with a lower confidence interval of 80% is desired. Dual Use: Antimalarial prophylaxis is required by both soldiers and civilians traveling to areas of risk. Civilian use of the invention, if successful, should be profitable.

REFERENCES:

KEYWORDS: implant, transdermal, drug, drug delivery, compliance, adherence, antimalarial, drug development, life-saving, military, soldier, malaria, Liberia, special operations

A04-202 TITLE: Metabolic Engineering for Performance Enhancement

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Identify and validate metabolic constituents that would serve as food supplements to enhance an individual's potential to perform physical and cognitive tasks under stressful situations.

DESCRIPTION: The identification and quantification of metabolic limiting factors of biological energy generation under stressful situations, such as hypoxia, will provide a basis for developing a strategy for nutritional supplements to ensure that a warfighter performs at maximum potential level despite combat stress. In principle, one's ability to be vigilant, to react quickly, to recognize patterns, to acquire targets, to make decisions and then to act upon them depends on the properly trained individual's cellular metabolism and on the level of physiologically active constituents, especially energy reserves and the metabolic conversion of substrate molecules to neurotransmitters and bio energy sources, especially ATP. Different tissues preferentially utilize substrates like glucose, lactic acid, fatty acids or amino acids, so these differences must be taken into account. The substrate fluxes rise and fall depending on nutritional intake and on physical and psychological demands. A metabolic engineering approach is needed to assess rate-limiting steps of energy metabolism, especially that involving carbohydrates, in key tissues to probe for possible enhancement of the efficiency of metabolic energy generation by adding to selected carbohydrate energy sources cofactors that are vitamin or micronutrient derivatives or selected natural antioxidants to enhance the efficiency of oxidative metabolism under stress. Optimal performance may then be assured through dietary intervention with targeted metabolic enhancing supplements.

PHASE I: Based on a knowledge of energy metabolism in cellular or tissue systems, several promising combinations of carbohydrate substrates with antioxidants or other enhancers of cellular energetics should be identified and tested in appropriate in vitro systems and/or metabolic models. Critical care medicine may provide examples of metabolic support in the form of alternative substrates, cofactors or anti-hypoxic agents. Some evaluation of metabolic conversion and cellular regulation are needed before pilot whole-animal model studies are designed. Appropriate measures of biochemical efficiency such as respiratory rates over time and respiratory control, P/O and redox cofactor ratios and cellular or tissue viability, including toxicity testing should be made. Each candidate supplement should be also assessed in terms regulatory status as food supplements, stability and suitability for selected modes of nutrient delivery to human subjects. Preliminary toxicity screens should also be conducted.

PHASE II: Validate the suitability of one or more of the most promising supplements. This validation demands experimental verification with animal or human subjects in selected stressful conditions. Validated exercise stress tests should be conducted; it is preferred that both physical (e.g. time to exhaustion or recovery rates) and behavioral (e.g. maze running) tests be conducted. A candidate delivery system and dosage schedule for the supplements will be developed in conjunction with NSC and USARIEM scientists. Evidence must be acquired or generated to show the direct correlation of dosage of supplement(s) with one or more markers of cognitive or physical performance.
PHASE III DUAL-USE APPLICATIONS: All segments of the civilian population engaged in stressful and critical activities could apply such metabolic enhancers. These activities include police, firefighting, air traffic controllers, medical personnel, and operators of transportation and power-generating facilities as well as elite athletes.

REFERENCES:

KEYWORDS: performance, energy metabolism, nutritional supplements, stress metabolism; hypoxia and nutritional status.

A04-203  TITLE: Miniature, Low Cost Real-Time Weather Sensor for Airdrop

TECHNOLOGY AREAS: Sensors, Human Systems

ACQUISITION PROGRAM: PM Force Sustainment Systems

OBJECTIVE: To develop and demonstrate a low cost wind sensor that would provide real-time measurements of winds ahead to a guided airdrop system during descent to a desired impact point. This information would be used by the autonomous guidance and control system to improve its overall landing accuracy performance.

DESCRIPTION: The US Army is developing a range of gliding cargo parachute systems that will be used for high altitude, large offset missions. Recent changes in military doctrine favoring small, widely-dispersed units operating relatively autonomously deep within hostile territory have emphasized the need for precision re-supply without the benefit of long, difficult-to-maintain ground supply lines. The proliferation of personal weapons capable of harming low flying supply aircraft have led the Air Force to want to deliver supplies from above 20,000 feet, further complicating precision airdrop technology. Research under the Air Force New World Vistas Precision Airdrop System (PADS) has greatly improved the landing accuracy of ballistic parachutes through detailed wind prediction and deaccelerator system modeling in the calculation of the Computed Aerial Release Point (CARP), but the desire for a long standoff distance requires high-glide systems, like parafoils. The Army Precision Extended Glide Airdrop System (PAGASYS) has developed a series of such systems with great promise, and the use of GPS navigation and guidance can even further reduce landing error.

Nevertheless, the difficulty of predicting/modeling ground winds leaves a significant wind uncertainty during final approach that contributes to a residual landing error. Future autonomous Guidance, Navigation and Control (GN&C) systems that must steer the cargo payload extremely accurately to a point on the ground must eliminate this error. Analytical studies have shown that inclusion of a sensor on the descending payload to measure winds ahead would contribute considerable to reducing this error source, and thus greatly improve landing precision.

Example technologies that might be able to satisfy this objective include weather radar and lidar. Desired performance for a production sensor would be as follows:

- Measuring winds (magnitude and 3D direction vector with respect to a local-horizontal local-vertical reference frame) out to a distance of 1000 feet ahead of sensor;
- Unit cost (lots of 100) threshold $ 2K; objective < $ 1K;
- Weight threshold 2 pounds; objective < 1 pound;
Form-factor to integrate readily into a conventional aerial delivery airborne guidance unit or cargo delivery pallet, requiring no modifications to transport aircraft;
Operational altitude threshold 18,000 feet; objective 25,000 feet;
Able to withstand parachute opening shock of 5 Gs and operate in the widest variety of weather conditions,

PHASE I: In this phase, sensor designs should be investigated and analyzed. Analyses should be conducted to estimate the achievable performance of a fielded system. Trade studies should be conducted to establish the relationship between cost and look-ahead distance, wind magnitude and direction resolution, weight, and power. Developing a preliminary design would be a plus.

PHASE II: In this phase, a prototype system should be developed and laboratory-demonstrated. Based on the results of all analyses and test results obtained, designs should be revised to better meet performance requirements. A second-generation prototype unit in an operational form factor as described above should be developed. This sensor should be demonstrated in flight tests provided GFE at the U.S. Army Yuma Proving Ground or similar facility.

PHASE III DUAL USE APPLICATIONS: This technology can be adapted to a variety of autonomous air vehicles and/or precision guided munitions requiring ultra-precise wind knowledge along their flight path. Guided airdrop systems used for getting critical supplies into a broad array of critical humanitarian relief situations (airplane crash in inaccessible terrain, earthquake, etc.) would also benefit with wind sensor augmentation of the airdrop guidance system.

REFERENCES:

KEYWORDS: Airdrop, wind sensors, wind measurement, parachutes, cargo parachute systems, and autonomous airdrop systems

A04-204 TITLE: High Performance Rechargeable Conformal Battery

TECHNOLOGY AREAS: Nuclear Technology

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a high performance man-wearable rechargeable battery for use in combat by standard infantry rifleman.

DESCRIPTION: This SBIR has two principal goals: (1) push the state-of-the-art of rechargeable lithium batteries to new levels, and (2) increase the technology readiness level (TRL) of man-wearable conformal batteries. More specifically, this SBIR will increase the specific energy and energy density of a complete packaged rechargeable battery to 200 wh/kg and 490 wh/l, respectively. In addition, TRL level will increase from 4 to 6 for a man-wearable body-conforming rechargeable battery by using materials appropriate for use in a combat environment.

Rationale for the conformable battery is as follows: Land Warrior currently uses two large prismatic-shaped rechargeable batteries in a centralized architecture. During early evaluation by the Rangers, soldiers complained about the difficulty of connecting cables to the batteries because two hands were needed and this was difficult to do
in the dark with gloved hands. Converting the batteries into a conformal shape and integrating them into the Scorpion/Objective Force Warrior chassis addresses the Ranger’s complaint because it allows for “blind” connectivity. Another issue raised by Ranger evaluation was size and weight. Conformal shaped battery addresses this also by using a body-hugging slim profile that distributes weight over a wider surface area.

PHASE I: The goal of Phase I is the development of a safe, lightweight, slim, flexible, packaged body-conformal rechargeable battery encased in protective material such as Viton. Battery capacity shall be as high as possible, preferably a minimum of 240 wh at an average draw of 20 watt and a maximum 16.8 volts. The weight shall be as low as possible, preferably less than 1200 grams. The physical dimensions shall be no greater than 22.86 cm x 10.16 cm x 1.905 cm (9 inches x 4 inches x 0.75 inches). At least two working prototypes operating on a bench top shall be demonstrated at the end of this Phase. In addition, four non-functioning mockups shall be fabricated.

PHASE II: The goal of Phase II is the development of working prototypes of conformal batteries, that can be fielded, and at least four non-functioning mockups that meet all the test requirements in the Land Warrior battery and MIL-PRF-32052. Reliability, affordability, thermal and EMI signature issues, and mass-producibility issues shall be addressed.

In addition, prototype smart battery chargers for these batteries shall be developed. Preferably these chargers will work from ac and dc sources available on the battlefield, and recharge a completely discharged conformal battery within two hours. The charger design should include an option for adding additional channels for battery recharging and possibly a modular design to accommodate such a capability.

PHASE III DUAL USE APPLICATIONS: If the research is successful, the Army may request approximately 200 body-conformal batteries to be fabricated for use in testing and to support the OFW ATD. In addition, at least 20 smart chargers developed in Phase II and built rugged for field use would be required. Comprehensive safety assessment tests will be conducted.

Numerous potential users of body-conformal batteries include: firefighters, HAZMAT personnel, security personnel, civilian police force, etc.

REFERENCES:
1) http://www.media.mit.edu/wearables/papers.html

KEYWORDS: Rechargeable battery, portable power, body-conformal battery, lithium ion, lithium polymer

A04-205 TITLE: Smart Terrain for Autonomous Agent Applications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: This effort will research the data and information elements that must be contained within terrain databases to enable inclusion of autonomous agents within combat simulations. The effort will also research methods of implementing these information elements within common terrain formats and consistent with a variety of inference engines and methodologies. The emphasis will be on terrain features/objects of military significance to the individual dismounted combatant that support modeling of dismounted infantry combat operations.

DESCRIPTION: Current generation combat simulations generally have a heavy reliance upon human operators. For certain applications, this reliance upon humans-in-the-loop has several serious drawbacks, to include repeatability and being labor intensive. Correcting these deficiencies through inclusion of Human Behavior Representation (HBR) in military operational simulations requires that autonomous agents be able to react to, and make use of, terrain and cultural features in decision-making. This imposes a need for imparting additional
information not found in traditional terrain databases that describes those attributes that impact on decision-making and/or physical interactions with environmental features. Many of the needed attributes are perceptual and dynamic in nature. Examples include; building entry points, areas of cover and concealment, areas of tactical importance, danger areas, choke points, etc. This information gap may be addressed through the use of overlays on the terrain that contain content needed by autonomous agent inference engines. The information provided by such overlays would typically be known to a human observer, but not inferred by an autonomous agent in a constructive simulation. The overlays will provide information and attributes that will allow the entities to interact in an intelligent manner with the physical environment. The benefits of augmenting terrain with such overlays include more robust OPFOR behaviors in training simulators, supporting development of semi-autonomous robotic vehicles, and more robust modeling of HBR in RD&A orientated constructive simulations. In particular, research into the required information elements will support the examination of the decision processes that underlie HBR and the assessment of dismounted infantry situational awareness. Research is also required into the tools needed to provide analysts a capability to create and modify these overlays, as well as providing simulations such as the Infantry Warrior Simulation (IWARS) the ability to access them. Critical issues pertaining to tools needed to create the overlays include, but are not limited to; compatibility with terrain formats of interest to the DoD, compatibility with commercial terrain generation and editing tools, extensibility, ease of use, cost, file size and run time constraints. More generally, libraries of generic overlays and tools to generate and modify them can support a spectrum of the DoD’s constructive simulation tools. Also, research into semantic overlay methodologies can support creation of decision and planning support tools identified in TRADOC Force Operating Capabilities (FOC).

PHASE I: Phase one will provide the conceptual basis for this effort, beginning with determination of required overlay types and associated attributes. Phase I should also assess the extent standard input formats, such as MultiGen OpenFlight, Compact Terrain Database (CTDB), the Environmental Runtime Component (ERC) or the SEDRIS Transmittal Format (STF) would allow for semantic overlay extensions with its associated data and information attributes. Phase I should also assess the method that would be utilized to create and modify these overlays. Phase I should conclude with the development of a proof of principle overlay for some selected terrain and operational scenario. Phase I deliverables should also include; 1) a small library of semantic overlay types, with associated attribute values and 2) assessments of the methods to be used to create and modify these overlays.

PHASE II: Phase II will provide for a more complete determination of required overlay types and associated attributes. Also, investigate decision aid semantic overlay content planned for decision and planning support tools identified in TRADOC FOC. Phase II would follow-up conceptual definition with development of tools, such as a visual editor, for construction and modification of terrain overlay libraries. These libraries need to be consistent with existing terrain formats and with the autonomous agent representations within the IWARS (documentation currently in preparation). Phase II should also provide development of an Application Program Interface(s) that will allow the information within the generic overlays to be accessed by a variety of DoD simulations. The objective should be to reach a Technical Readiness Level (TRL) 6 by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: The developed methodologies and associated software products have obvious commercial applications in the world of first person shooter, role playing games and other simulation products that incorporate decision-making and human interaction with the physical environment. There are also applications for non-DoD agencies that employ operational simulations, as for example police and fire-fighting support and/or homeland security.

REFERENCES:

ARMY - 264
A04-206 TITLE: Detection of Protease Activity for the Identification of Biological Toxins and Exposure to Chemical Warfare Agents

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To develop sensitive and robust fluorescence based sensors for the detection of selected protease activity for the identification of biological toxins and exposure to chemical warfare agents.

DESCRIPTION: Proteases represent a large class of enzymes that catalyze the cleavage or degradation of other proteins; playing key roles in many biochemical processes including defense and survival mechanisms, programmed cell death and tumor angiogenesis. Several biological toxins possess protease activity including Bacillus anthracis lethal factor and Botulinum toxin (1, 2). In addition, specific proteolytic activity has been correlated with exposure to organophosphates and mustard gas(3, 4). The development of a sensitive, rapid, and deployable sensor technology to detect the presence of specific protease activity is the focus of this topic.

Several biochemical assays exist to detect and quantify the presence of protease activity by monitoring the hydrolysis of a specific peptide sequence labeled with radioisotopes or fluorescence tags (1, 2, 5). The most promising technologies include the use of fluorogenic synthetic peptide substrates with an internally quenched fluorophore producing fluorescent emission upon cleavage of this specific peptide sequence based on fluorescence resonance energy transfer and the use of superparamagnetic nanoparticles as magnetic relaxation switches (5). These approaches, however, lack the sensitivity required for the development of a field deployable sensor. These sensitivity limitations can be overcome by recent advances in fluorescent polymer based signal amplification technologies (6). Conventional fluorescence detection normally measures an increase or decrease in fluorescence intensity or an emission wavelength shift that occurs when a single molecule of the analyte interacts with an isolated chromophore. In that case, only the chromophore that interacts directly with the analyte of interest generates a signal (7). A variation of this approach is the “molecular wire” configuration, in which the absorption of a single photon of light by a chromophore will result in a chain reaction throughout the polymer amplifying the sensory response by several orders of magnitude (7). This self-amplification exhibited by these semiconductive luminescent polymers results from effective energy transport along the polymer backbone and between polymer chains (6). Fluorescence sensors based on these conjugated polymers are self-amplifying and can therefore display much higher sensitivity than traditional systems (6).

A successful resolution to this problem has the potential to detect a single protease molecule amongst a complex environment. In addition, this topic has very broad reaching applications from agent detectors to cancer diagnostic tools. Finally, these approaches could be extended to other hydrolytic enzymes, such as nucleases, polysaccharidases, and lipases.

PHASE I: Research, develop and propose a technique/system design with the potential of realizing the goals in the description above. Develop technical specifications for components and identify as commercially available or to be developed. Conduct necessary investigation on the design and performance of critical components to demonstrate the feasibility and practicality of the proposed technique/system design, including mitigation of risks associated with factors limiting system performance. Deliver a report documenting the research and development effort along with a detailed description of the proposed technique/system to include specifications of key components. Current technology readiness level is 3 (analytical and experimental critical function and/or characteristic proof of concept). Upon successful completion of phase I, a technology readiness level of 4 (component and/or breadboard validation in laboratory environment) or 5 (component and/or breadboard validation in relevant environment) must be achieved.
PHASE II: Develop the technique/system identified in Phase I. Fabricate and demonstrate the technique/system, then characterize and refine the technique/system performance in accordance with the goals in the description above. Deliver a report documenting the theory, design component specifications, performance characterization and recommendations for technique/system performance. A technology readiness level of 6 (system/subsystem model or prototype demonstration in a relevant environment) must be achieved for successful completion of phase II by the end of FY06.

PHASE III DUAL USE APPLICATIONS: A technique or system meeting the requirement outlined in this effort would be applicable in both military and civilian detection communities. Homeland defense and Food Safety arenas would reap a substantial benefit from this effort. The DoD medical community may also be able to apply this approach as new diagnostic technologies. For example, the ability to detect botulinum toxin benefits both the military and consumer food safety community. New applications in medical therapeutics for the treatment of muscular disorders and bacterial metalloprotease inhibition as a novel alternative to traditional antibiotics are attractive developments for the pharmaceutical community.

REFERENCES:

KEYWORDS: protein toxin, organophosphate, protease, food safety, biosensor, fluorescence detection

A04-207 TITLE: Solar Cogeneration of Electricity and Heat for Field Kitchens

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop an integrated, self-contained method to preheat water and provide electricity to operate burners for use in Army field kitchens. The system will use solar as an alternative energy source. Preheating water will decrease the need for open flame heating inside the kitchen. This will improve the kitchen environment by decreasing the temperature and exhaust emissions that are introduced. Providing electric power will eliminate the need for the internal combustion 2 kW generator, reducing emissions, noise, and maintenance requirements.

DESCRIPTION: Field kitchens can get extremely hot even in mild climates. In hot climates, this situation is exacerbated to the point of being unhealthy. The reason for this is that large amounts of water need to be boiled and heated to prepare a standard military menu. A 2 kW generator is used to provide electrical power for the field kitchen/sanitation system. It is noisy and maintenance intensive. To feed 275 soldiers, two meals per day, approximately 80-gallons of water (40 gallons per meal) is heated, requiring 0.41 kW-hrs for every degree C rise in temperature. The electrical requirements for the field kitchen and sanitation center is approximately 9.1 kW-hrs per day. Electricity is used to power lights, burners, and pumps. The Mobile Kitchen Trailer (MKT, the predominant field kitchen) has an aluminum fixed section of roof and a fabric section that is set-up when deployed. The fixed section of roof is 6.7 square meters in area and the fabric section is 10.6 square meters in area. Solar energy available to the MKT without exceeding its envelope is approximately 6.0-8.0 kW-hrs/m2/day in a location such as Arizona or other desert environment with similar cloud cover. The theoretical energy available under these conditions is 40.6 kW-hrs/day on the fixed section and 63.8 kW-hrs/day on the fabric section.
section for direct conversion of solar energy to heat would require an efficiency of 68% to achieve the minimum desired temperature increase of 68° C and an output temperature approaching 100° C. Achieving this level of efficiency with a medium temperature collector will require pushing the limits of the state of the art in advanced coatings. Achieving higher efficiencies and output temperatures would increase the systems effectiveness and attractiveness as any excess hot water produced could easily be applied to the sanitation center (co-located with the kitchen), which requires up to 120 gallons of heated water per meal. Using the flexible portion of the roof to generate electricity directly would require an efficiency of 14% to meet the needs of the field kitchen/sanitation center system. Cost will be a consideration of the final product, so the efficiency of the photovoltaic collector will not be as important as the ability to produce and deploy it easily and inexpensively. An electrical storage system would be included to provide power consistently throughout the day. The system developed must be an integral part of the kitchen roof system. It must not interfere with the operation of the roof vents and be easily deployed with the set up of the kitchen. The system must be robust and light, containing a self-powered control system to keep the system operating in its optimal range in a variety of conditions and locations. The system must be safe, operable with little or no training, and easy to clean.

PHASE I: Develop a detailed design for the proposed system and provide information to determine applicable global locations for such a system. Calculate performance in various locations around the world. Estimate the weight and cost of the fieldable product.

PHASE II: Complete the design and development of the complete solar system. Fabricate one prototype system to include the complete water storage and delivery system, controls and safety systems.

PHASE III DUAL USE APPLICATIONS: Beyond water heating for all levels of field-feeding facilities, systems that provide managed hot water and electricity would be immediately applicable to Force Provider shower and laundry facilities. With a little more development, the systems could perform waste-water distillation/purification and desalination recycling to reduce the costs of supplying fresh water product during wartime operations. In the commercial sector, as costs for fossil-fuels and electricity inevitably increase, and technology-advances render photovoltaics and other subsystem components more affordable, a crossover point will be reached to encourage use of these systems in urban and rural homes, housing in developing countries, and by car-campers who desire convenient showers and/or instant hot water for beverages and food. In all cases, the military and consumers would benefit from the relatively low cost of distributed electricity production without the costs, noise, and pollution associated with diesel generators.

REFERENCES:
2) SRCC (Solar rating and Certification Corporation), Standard OG-100.
8) Basic Doctrine for Army Field Feeding and Class I Operations Management, FM 10-23.
10) Technical Manual for the Food Sanitation Center, TM 10-7360-211-13&P.

KEYWORDS: Solar power, field kitchens, food, water heating

A04-208 TITLE: Variable Glide Aerial Delivery Parachute Systems

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Force Sustainment System
OBJECTIVE: To develop and demonstrate a variable glide aerial delivery parachute system for improved accuracy and maneuverability during controlled flight. The ability to rapidly change the system’s configuration and glide performance with minimal control inputs will allow for more optimum control, maximum flexibility in release locations and significant improvements for ground impact point accuracy for a larger range of payload weights and applications.

DESCRIPTION: The US Army envisions the development and fielding of a variety of precision airdrop systems (Reference 1 - 5) for use in delivery of cargo or varying weights and sizes, vehicles and potentially warfighters. Commercially available systems utilize decelerators that have only a small range of control over their lift to drag ratios or a one-time control maneuver such as a parafoil flare just prior to ground impact. Parafoils are the most commonly known systems that allow for little flexibility over the lift to drag (L/D) ratio during flight. The ability to change the L/D while in flight from zero or very near zero to values of 3/1 or greater while still assuring control over the vertical velocity which must remain within survivability limits of the payload/warfighters at ground impact will allow for more in-flight control, greater ground impact accuracy and greater payload survivability. Concepts to rapidly change from forward controlled flight to ballistic vertical descent are desired for tighter control. The ability to switch from fwd flight to reverse flight directions without turning the system around is desirable. Final ground impact accuracy is strongly linked to L/D and ground winds. Ground winds are the most difficult to predict and/or measure during an autonomous airdrop mission (Reference 6 & 7). The ability to rapidly adjust a systems glide performance will significantly enhance near ground impact control and touch down accuracy. In flight control of vertical velocity is also desirable but vertical velocity must be minimized for ground impact. The use of minimum energy and control for switching L/D’s is desirable with use of potential energy to perform these changes as the most desirable. Concepts proposed should be scalable for use in as wide a range of payload weights as possible. The total range of payload weights for which the concept should be applicable is 200-10000lbs. Minimizing the number of sizes necessary to span this range should be considered.

PHASE I: In this Phase, new variable L/D parachute concepts and innovative technologies/methodologies to fabricate and control such systems should be developed with the focus on low cost, maximum L/D flexibility, simplicity, and re-usability for a range of potential payload configurations and weights. Attention and thought must be given to the systems ability to deploy from high-performance aircraft flying at standard airdrop speeds (i.e., 130-150KIAS) and from altitudes ranging from very low altitudes (payload weight specific) to altitudes of 25,000ft MSL. Upon a concept down-selection, prototype system design and fabrication of a scaled system capable of delivering payload weights from 50-500 lb range is desired. If concepts are ready, the government will provide airdrop test assets as government furnished equipment (GFE) at the US Army Yuma Proving Ground for a series of flight demonstrations. Predictions of L/D ranges should be attempted with simulation tools and/or comparison. The measurement of low L/D values will be provided as GFE. Strategies for control of L/D along with turn control or arbitrary transition to a constant direction of flight are desired. Development of computer models for control of the systems/concepts is not recommended in this phase.

PHASE II: Demonstrate the concept via more detailed design and construction of systems for the largest range of payload weights listed. Demonstrate system control via radio controlled flight tests (as GFE at US Army Yuma Proving Ground or similar facility). A more detailed study of the systems scalability to the largest payload weights should take place with cost projections and comparisons to more typical commercially available gliding parachute systems should be made. Demonstrations of at least one system with a 2200lb payload (door bundle) with L/D control from 0 to at least 3 to 1 is desired with other steady state values attainable for long durations of flight within the systems L/D range. A detailed cost analysis that includes rigging time and re-configurations should be conducted.

PHASE III DUAL USE APPLICATIONS: This technology could be applicable to all types recreational airdrop systems. Sports enthusiasts are regularly pushing the high-performance sports parachutes to smaller sizes that have very high forward speeds and very high L/D’s resulting in rapid horizontal impact speeds without pin point control. This concept will allow jumpers to range their L/D, land more accurately and more safely than with traditional commercially available systems.

REFERENCES:

KEYWORDS: Airdrop, parachutes, cargo parachute systems, and autonomous airdrop system, textiles


TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop new azobenzene dyes with fast response time, increased photoanisotropy and increased broadband spectral response for broadband laser eye and sensor protection.

DESCRIPTION: Current frequency agile laser eye-protection schemes for the individual soldier rely on nonlinear optical (nlo) dyes. These designs utilize focusing optics to obtain high fluences required to trigger an nlo mechanism, which, for example, could be excited-state, or two-photon absorption. Focusing optics are problematic due to issues regarding field-of-view, image quality, and bulk/weight considerations. For this reason, new laser eye and sensor protection schemes are required that do not require a focal plane. Some new concepts, such as polarization rotation, have recently been explored. Optical power limiting (without a focusing lens) has been demonstrated for low power continuous-wave lasers at one wavelength based on intensity-dependent photoanisotropy induced by polarized light in azobenzene polymer films. The goal is to apply the same technique for high power pulsed lasers. However, in order for the approach to be feasible, there are several issues to be addressed: The response time for azobenzene solid films is currently on the order of milliseconds. Recent experimental data has indicated a response time of tens-of-picoseconds for azobenzene solutions. This research would attempt to decrease the response time of solid samples to hundreds of picoseconds or better. The material must also have broadband response over the visible region. It is not necessary that a single dye respond to the entire visible range of 400-800 nm. It is necessary, however, that the spectral response of combinations of dyes excites the eye at a number of smaller bands over the visible spectrum. The magnitude of the photoanisotropy must be enhanced for practical device application. The goal is 40% transmission for a vision device under ambient conditions. The design and synthesis of new azobenzene materials may help in solving these problems.

PHASE I: Research, develop and propose a technique(s) by which to address the issues and realize the goals in the description above. Conduct necessary optical, experimental evaluations of the dyes to demonstrate the feasibility and practicality of the proposed approach/solution. Investigate risk factors limiting system performance and describe how they might be overcome. Deliver a report documenting the research and development effort along with a detailed description of the proposed approach/solution. The Phase I will achieve Technology Readiness Level 3 (TRL-3).
PHASE II: Develop the approach/solution identified in Phase I. Synthesize and demonstrate the material improvements by incorporating the improved dyes in a laser light-blocking scheme. Characterize and refine the technique/system performance in accordance with the goals in the description above. Deliver a report documenting the theory, design, component specifications, performance characterization and recommendations for technique/system performance. The Phase II will achieve TRL-6.

PHASE III DUAL USE APPLICATIONS: A technique or system meeting the requirements outlined in this effort would be applicable in both military and civilian arenas. The civilian law enforcement community would reap a substantial benefit from this effort, as would researchers and those in industry who work with high and low power lasers. The Phase III will achieve TRL-8.

REFERENCES:

KEYWORDS: Azobenzenes, polymers, thin films, optical power limiting, laser eye protection, laser sensor protection, photoanisotropy, high power lasers

A04-210 TITLE: Solar Refrigeration

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop a refrigerated container that will operate primarily from solar energy

DESCRIPTION: The Army has included provisions for Preplanned Product Improvement (P3I) in the Multi-Temperature Refrigerated Container System (MTRCS) Operational Requirements Document (ORD) calling for innovations such as alternative energy sources. Current refrigerated 8x8x20 ISO containers need 2.6 kW (9000 BTU/hour) of cooling driven by the military's 16.4-kW (29.5-hp) diesel-engine 10kW generator. The 10kW generator burns about 4 liters (~1 gallon) of fuel per hour and requires significant scheduled and unscheduled maintenance. It is anticipated that the similarly sized but more efficient MTRCS will still require a 5.6 kW (7.5 hp) diesel engine. Using solar energy instead would significantly reduce fuel and maintenance costs, especially in sunny desert environments such as the Middle East. In addition to these immediate benefits, solar-power technologies should be implemented wherever possible in recognition of the fact that many fossil fuel experts project global oil
production rates will peak within the next 10 to 20 years, followed by diminishing supplies. Given that there is no known substitute for jet fuel, it is unlikely to be available for powering refrigerated containers. Accordingly, it is desired the MTRCS diesel engine be replaced with a roof-mounted photovoltaic (PV) array. This array will charge batteries that will, in turn, power the refrigeration compressor and air circulating system. By matching array output to battery capacity and the refrigeration system power draw schedule, optimum energy management will be achieved to ensure maintenance of food-safe temperatures at night and during periods of cloud cover. Novel low-power, efficient compressors, evaporators, and condensers should be considered to minimize overall system cost, weight, cube and complexity. Solar-heat driven and heat storage innovations will be considered as well. In a worse-case scenario, a back-up generator can be connected to the batteries if low voltage is detected--Phase I will evaluate the necessity of this contingency. It is desired the solar collector fit within the envelope of the roof; however, expandable arrays and configurations that follow the sun will also be considered, provided they can withstand wind loads. It is desired the system function to keep the container cold during transit, but the primary focus will be for stationary applications. Sandia sponsored a feasibility study for a commercial solar-powered 16.2-meter (53-foot) refrigerated trailer in 2001. This study should be used as a reference.

PHASE I: Perform a feasibility study for a military solar-powered refrigerated container based on the following requirements: The standard certifiable 8x8x20 ISO container will have a double door opening on one end. The system must be capable of maintaining a temperature between 0.6C (33F) and 5C (41F) 24 hours a day in ambient temperatures ranging from -32C (–25F) to +52C (+125F). It shall weigh no more than 4536 kg (10,000 pounds), empty. The internal dimensions shall be suitable for storing 14 standard pallets of rations. The electrical system shall suitably be for storing 14 standard pallets of rations. The electrical system shall allow connection to shore and generator power (120/240V AC). The annual solar energy, ambient temperature, and wind-load cycle of Phoenix, Arizona shall be used for design. The study should baseline the performance and life-cycle cost of a system constructed of conventional low-cost solar-powered materials, refrigeration components, and container walls and seals. Several innovative technology improvements that enable performance goals to be met will be identified. Those improvements include reducing the heat loss of the container, improving the refrigeration system efficiency, optimizing energy storage and delivery, and developing a compact, practical, robust, and efficient, photovoltaic array. Small-scale technology demonstration of selected design elements shall be used to verify improvements and establish proof-of-principle. A final report will be delivered that specifies how requirements will be met. The report will also detail a conceptual system design, performance modeling, safety and MANPRINT, estimated production costs, estimated operating costs including fuel, spares, and maintenance requirements, and system trade-offs (solar vs. diesel) for the above areas.

PHASE II: Fabricate a solar-powered refrigerated container to meet the Phase I requirements. The container will be suitable for limited field-testing and technology demonstration. Strict attention to MANPRINT and safety factors will be observed. Additional features such as defrost, lighting, temperature recorder, alarm system, microprocessor control systems, high-efficiency insulation, leak-proof door gaskets, and cargo tie-downs shall be included in the prototype.

PHASE III DUAL USE APPLICATIONS: As the price of photovoltaic power decreases, new opportunities for its use develop. Maintaining refrigerated space does not take an enormous amount of power as compared to transportation or even field kitchens. The relative cost of power produced by small diesel engines is high, not only in terms of operating and maintenance costs, but in terms of noise and air pollution. Solar-powered refrigeration offers an ideal application for photovoltaics. Containers offer a significant structure and surface area on which photovoltaic arrays can be mounted. The use of solar power will reduce fuel consumption and costs for military and commercial refrigeration alike.

REFERENCES:
4) NRDEC Performance Purchase Description PD 415, “Refrigerator-Container, Field, 8 Feet By 8 Feet By 20 Feet”, 30 January 1998.
A04-211  TITLE: Onsite Field-Feeding Waste to Energy Converter

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To demonstrate the ability to treat field-feeding solid waste as a resource, producing useful energy or fuel from the waste decomposition process.

DESCRIPTION: Field feeding produces tons of packaging and food waste that must be backhauled to disposal sites at great expense. An onsite field-feeding waste to energy converter (OFWEC) would reduce or eliminate this enormous logistic burden while reducing waste to nonhazardous byproducts and producing useful energy.

Recent studies show that solid waste is generated at a rate of 3-4 lbs per person per day for field exercises, short-term deployments, and steady-state base camp operations; 80% or more of this is generated by food-service operations. A typical maneuver battalion or Force Provider complement of 550 soldiers will then produce about 2000 lbs of solid waste per day, suggesting an OFWEC processing rate on the order of 100-200 lbs/hour. This waste is mixed, and the users cannot be relied upon to segregate it, except possibly to remove metal cans. A solid waste study at Fort Polk characterized the waste stream as follows: 41% food waste, 38% paper and cardboard, 12% plastic, 3% metal and glass, and 7% miscellaneous, with an overall heat of combustion of 6500 BTU/lb. Waste composition can vary considerably by meal and location; an earlier study at Fort Campbell found a significantly lower proportion of food waste and higher proportion of metal and glass.

The OFWEC system should process field-feeding waste to realize weight and volume reductions greater than 80% while producing useful energy from the waste decomposition process. Potentially desirable solutions include converting the organic matter in the waste stream into electrical power, high-quality fuel-oils, and/or clean-burning gases. Electricity generated should be 120V or 120/240V, single phase, 60Hz for compatibility with field-feeding equipment. For any oils produced, it would be advantageous to have characteristics similar to JP8 for safe combustion in generators, kitchens, or vehicles. Gases produced would likely be used onsite at or near the generation point to power the process and generate electricity, although it may also be possible to heat water for showers or kitchens. Potential OFWEC technologies include, but are not limited to, thermal depolymerization, hydrothermal oxidation, pyrolysis, gasification, and fuel cells. In general, combustion-based incineration approaches are unlikely to be responsive to this topic, as incineration is viewed as a mature technology, is generally inefficient for energy production, and generates emissions and wastewater requiring permitting, monitoring, and special handling.

The entire system should be containerized and transportable for rapid deployment, self-contained in an 8x8x20' ISO shipping container (objective 8x8x6.5' Tricon) for compatibility with Force Provider. System weight should not exceed 10,000 lbs (objective 5,000 lbs) for compatibility with Army forklifts and 2.5-ton trucks. A smaller, lighter, and affordable system would be more suitable for highly mobile units, and could expect significantly more widespread adoption. The OFWEC should include all necessary pre-processing/sizing/grinding equipment and pollution control systems. The system should have automated control and operation to minimize human resource requirements, should be rugged and low-maintenance to minimize operational costs, and should have few consumables to minimize logistical requirements. In accordance with a "Zero Footprint" philosophy, any OFWEC-generated wastes or residues should be benign to the environment and safe for equipment operators.

PHASE I: Establish the feasibility of a waste to energy converter concept that meets the operational requirements stated in the topic description by conducting research to demonstrate that the approach is scientifically valid and practicable. Mitigate risk by identifying and addressing the most challenging technical hurdles in order to establish viability of the technology or process. Perform proof-of-principle validation in a laboratory environment, and characterize effectiveness through experimentation with simulated field-feeding solid waste. Address environmental regulations, safety, and human factors concerns, and provide credible projections of practical scales to which the technology can be applied (e.g., battalion vs. company-sized feeding operations).
PHASE II: Refine the concept and fabricate a prototype system that meets all operational, effectiveness, and reliability requirements and is sufficiently mature for technical and operational testing, limited field-testing, demonstration, and display. Address manufacturability issues related to full-scale production for military and commercial utilization. Observe strict attention to safety and human factors. Provide user manuals and training to support government testing of the equipment.

PHASE III DUAL USE APPLICATIONS: This basic waste processing technology targets military field-feeding food and packaging waste, but can also support emergency response and disaster-relief activities. Potential commercial applications include outdoor events such as fairs, carnivals, and camps, as well as indoor food-service such as lunchrooms and cafeterias. On larger scales, it could handle waste from institutional or consolidated food service and industrial food production plants. The technology may also be suitable for human waste on a small scale, such as military latrines, or on a large scale, such as low-moisture municipal sewage processing. An onsite waste to energy conversion capability offers attractive opportunities for distributed waste processing and fuel or power generation.

REFERENCES:

KEYWORDS: waste to energy, solid waste, food waste, packaging waste, waste reduction, waste processing, alternative energy, environmental compliance

A04-212 TITLE: Shelter Fabric and Soldier Uniform Textile-Mounted Electronic Displays for Military Command Functions

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM TOC Integration

OBJECTIVE: Develop ultrathin, flexible color electronic displays (with high pixel density and resolution) that can be laminated on soldiers’ uniforms and on interior and exterior shelter fabrics for communication/command/control applications. The size of these displays will be less than 18 square inches on glove and uniform sleeves and could be as large as 4 square feet for shelter fabrics. Inside the shelter, these flexible displays would be mounted directly to the shelter liner or exterior fabric or could be rolled out on tables. The shelter displays would have direct application for use in command/control shelters and in medical shelters.

DESCRIPTION: Electronic displays are a rapidly developing technology that will lead to wearable displays, electronic books, large-area displays, and display screens for cell phone and digital watches. Compared to conventional electronic displays, electronic ink applications are brighter; more readable; more portable, thinner and lighter. They also consume significantly less power than LCD technology. Fabricated onto bendable active-matrix-array sheets, these displays have resolution sufficient for reading (160pixels x 240 pixel density); can be rolled into a cylinder; and are erasable and reusable. The military would greatly benefit by such displays for communications, maps, construction drawings, and computer screens. Through this SBIR, large-scale electronic displays would be adapted for both exterior and interior military use by integrating this technology directly onto soldiers’ gloves and uniforms and onto shelter fabrics.
Electronic displays use a material composed of microcapsules suspended in a clear liquid. When the microcapsules are electrically charged, a colored display appears. This material is printed on a plastic film laminated to circuitry. This microcapsulate system is processed into a film that can be glued or printed onto fabric (and many other material) surfaces.

As shelters and uniforms become multi-functional, there exists a need to embed display technology directly into the fabric itself. This proposal seeks to develop this technology as low power consuming military display tools that can be easily deployed and possess low cube and weight. As these communication tools may be either interior or exterior, they must be able to function without degradation when exposed to military (UV, rain, sand, wind, small object impacts) environments and must be easily repairable. Specific uses for this technology include communication, maps, and drawings, as well as smaller computer screen displays on uniforms or gloves of the electronic Soldier.

PHASE I: Research, develop, and propose an ultrathin, flexible laminate system that could be used for wireless low power electronic display technology, laminated glove material, uniform material, and exterior and interior shelter fabrics, and meet military environmental specifications. This system must work for small displays, up to 6 inches by 6 inches, on gloves and uniforms and for larger interior and exterior shelter displays up to 144 square inches. Exterior displays must operate in military environments (sand storms, rain, and snow). Interior displays should be suitable for receiving messages, and for displaying maps and construction drawings.

PHASE II: Develop and evaluate working prototypes of both exterior and interior displays that meet the specifications listed above. One small display prototype (small enough to fit on a glove) should be laminated onto warfighter glove material and should demonstrate the capability to receive and display a short message. A second prototype should: be of a size that would fit on a warfighter’s sleeve; be laminated onto a textile based uniform material; and demonstrate the capability to receive and display a short message. Two other prototypes, one laminated onto an interior shelter fabric and the second laminated onto an exterior shelter fabric, should be approximately 12 inches by 12 inches in size and should demonstrate the capability to receive and display a message and a visual image (i.e., a map). Develop a method for easily embedding an exterior display onto a soldier’s uniform and/or glove while minimizing the size and weight of the associated electronic hardware. Develop shelter electronic flexible displays while minimizing the size and weight of the associated electronic hardware. Develop a method for easily attaching (without tools) both the interior and exterior shelter displays to a fabric shelter. Consider durability, ease of repair, manufacturability, and cost in addition to performance specifications.

PHASE III DUAL USE APPLICATIONS: Flexible color electronic displays are currently under development for PDA’s, digital watches, electronic books, billboards, etc.

REFERENCES:

KEYWORDS: ultrathin flexible laminates, high resolution color electronic displays, fabric, textiles, shelters, tents, uniforms
OBJECTIVE: To develop and demonstrate a low cost high tenacity suspension line material and design, or a system of suspension lines that minimizes drag over the range of speeds common to decelerator systems for manned and controlled cargo flight. Low drag line design that is easily fabricated and price competitive to current suspension line materials is desired to allow for more lift to drag ratios (greater system offset) (Reference 1). The angle of attack of suspension lines to the airflow ranges significantly depending on the location of the lines relative to the decelerator. The suspension lines must be compatible with existing suspension line material in the areas of stow-ability, deploy-ability, and service-ability to assure a larger commercial market and seamless integration into existing and/or soon to be fielded systems. The ability to rapidly switch out suspension lines via larks head knots at the decelerator surface is desirable. Demonstration of a drag reduction of at least 50% or greater to equivalent strength suspension lines with minimal weight increase is the target objective. The suspension line system must adjust and align itself to the approaching air to minimize drag. Special rigging procedures for swapping out new suspension lines are not desired.

DESCRIPTION: The US Army as a wide range of gliding personnel parachutes systems in the inventory and is near fielding of a family of precision airdrop systems (Reference 2 – 6) that will have varying levels of Lift to Drag ratios. The ability to minimize the suspension line drag on such systems (which can be as much as 30-40% of the system drag) is desirable. Innovative, low cost concepts to fabricate new low drag suspension lines from existing commercially available and airdrop acceptable materials are desired. New materials will be considered but must be comparable to airdrop suspension line materials in strength, longevity (i.e., U/V resistance and storage pack times and environmental conditions seen by military parachute systems). Consideration of the use of existing airdrop materials with a modified fabrication process is encouraged.

PHASE I: In this Phase, new low drag suspension line concepts will be explored and traded off against all the key factors they must achieve for acceptability to the parachute industry. Common suspension line material should be used as the base line for comparisons of materials, designs, and construction concepts. In addition to a plan showing affordable manufacturing, prototype new suspension lines could be fabricated and tested for strength and drag compared to existing suspension lines and a study clearly showing the advantages and disadvantages should be a deliverable. Modeling of the new design and existing suspension lines could be included in this phase with predictions in overall performance increases (i.e. drag reduction) desired. Wind tunnel testing, if deemed necessary is acceptable but the costs should be included in offeror's proposal.

PHASE II: Fabrication of larger quantities of the new suspension line for personnel-sized parafoils of potentially varying strengths for implementation in sport and DoD airdrop system tests is recommended. Demonstrate the new suspension line systems on a variety of side-by-side tests on military parachute system (i.e., swap out new lines with old lines) and measure the increase in systems L/D along with swap out times required to estimate costs of conversions. These tests can include a number of parafoil and other decelerator designs. In addition, the scalability of the new lines for inclusion into a range of cargo size parachutes/parafoils is desired. Demonstrate a re-configurable system that adds minimal time to rigging and can accommodate the widest range of payload weights for the design/system chosen. Large parafoils, round and/or cross canopy systems could be proposed. Teaming with commercial and/or military parachute manufacturing companies for testing on non-DoD parachute systems is recommended.

PHASE III DUAL USE APPLICATIONS: This technology could be applicable to all sports parachute and emergency rescue systems, and fabric support structures (i.e., tent supports and tie down materials on trucks, trains, boats, airships etc.).

REFERENCES:

KEYWORDS: Textiles, airdrop, parachutes, personnel and cargo parachute systems, autonomous airdrop system, tents

A04-214 TITLE: High Efficiency Shelter Lighting Utilizing Solid State Illumination Technology

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Force Sustainment Systems

OBJECTIVE: Develop an advanced, high efficiency, light weight, rugged lighting system for battlefield shelters utilizing emerging solid state illumination technology that will integrate with flexible photovoltaics and provide sufficient and even light for applications such as medical and command/control.

DESCRIPTION: Recent breakthroughs in solid state illumination technology are making their way into the commercial market in the form of semiconductor light emitting devices (LEDs) in items such as flashlights, head lamps and traffic signals. These semiconductor devices convert electrical input directly into light. This technology will prevent energy loss to heat, which occurs through the use of both fluorescent and incandescent lighting. Currently available solid state lighting systems are ideal for small task areas but do not provide the general illumination required in military shelters. Recent advances in the brightness of LEDs are making general illumination technology possible. The goal of this project is to tailor the most suitable emerging solid state lighting technology and integrate it into military shelters to provide general area illumination.

In order to keep up with the rapid deployability of the U. S. Army, shelters must be provided to the soldier that provide an environment to facilitate mission critical functions. With the advances in rapidly deployable structures, the logistics of the associated equipment must be minimized. Currently deployed shelter systems lack a lighting system that is highly efficient, highly mobile, and integral to the shelter.

Photovoltaic technologies are currently being worked into shelter fabrics to provide energy for military applications. Photovoltaic materials can provide adequate power directly for integrated solid state lighting technologies (~20mA current requirements) but an insufficient amount for currently utilized fluorescent lighting (~700mA current requirements). Integrated solid state lighting would be powered by integrated photovoltaic materials, eliminating the need for additional bulky equipment.

Current Lighting: The lights included in Army shelter systems are fluorescent tube-shaped lights in ruggedized cases. These lights are larger and heavier than desired, especially for far forward operations. They come in bulky, rigid cases required for transport. Due to their size and fragility, these fluorescent lights cannot be rolled up with the tent but installed after the tent is standing, adding to deployment time. The smallest light is 2.5 feet long and weighs 5 pounds. Several of these lights are required to meet lighting requirements (typically greater than 65 foot-candles at working level). They have an electric ballast, life expectancy of approximately 14,000 hours, and are expensive. In addition to being both bulky and expensive, these lights have higher power requirements than desired. Currently utilized fluorescent lighting could not be powered by emerging integrated photovoltaic materials. They also emit a low quality light, lower than both solid state lighting and incandescent, which does not help to improve soldiers work performance. Fluorescent light wastes energy as heat by converting only a portion of its ultraviolet radiation and is also a potential hazard since it contains mercury.
Future Lighting: Solid state lighting, such as Light Emitting Diodes (LEDs) offer a number of advantages over fluorescent lights including a major reduction in energy and up to a ten times increase in lifespan. Solid state lighting does not generate radiofrequencies or emit ultraviolet components, increasing stealth of a shelter system. They can potentially deliver 100% of energy as light, leaving no energy wasted as heat. Studies have shown that human performance is enhanced when exposed to certain lighting conditions such as solid state, which is of interest to benefit soldier performance.

Advances in LED lighting technology make it possible to produce variations of both white and colored light using a small semiconductor chip and a low current of electrical energy. White solid state lighting can be achieved through use of multi-colored LEDs which emit white light when combined or through use of Blue LEDs and phosphor. The lighting provides good visibility, high efficiency and extremely low power requirements.

Whether the shelter is used as a command center, communications center, or medical facility, an ideal light source will be rugged, have a low profile, provide bright light, require low power, and be integral to the shelter to enable rapid deployment.

PHASE I: The intention of Phase I of the program is to investigate innovative materials and concepts that will lead to a highly advanced solid state lighting system that emits white light with low power requirements and is optimized for military shelter applications. Solid-state lighting technologies will be examined and selected based on light output, efficiency and power consumption. Semiconductor materials will be investigated, down-selected and optimized to address the desired performance objectives. The ideal solid state lighting technology will then be integrated into military shelters.

The selected technology should be mature enough to ensure the shelter lighting system is ready for military use and commercialization at the end of Phase II. Specific design considerations include reflector cup and epoxy lens materials. The criteria used in the investigation should be emission intensity, diffusivity, durability, efficiency, power consumption, quality of light and cost. The lighting system must be designed to withstand shock, vibration, switching, and a variety of environmental conditions. The light produced should be bright white, diffused with even coloring. A direct comparison of characteristics will be used to choose the most qualified technology and lighting system configuration.

PHASE II: The solid state lighting system developed during Phase I of the program will be developed into prototypes during Phase II. The lighting system will be integrated in a manner that allows for emerging photovoltaic technologies to potentially power the system without need of any additional external power source. Substrates will be evaluated to incorporate a collection of the LEDs into a lighting system. The substrate will be flexible, durable, cost efficient, flame resistant, and integrated into a soft shelter. The system of LEDs must be designed so that it provides a sufficient amount of light using the least amount of LEDs, conforms to National Electric Codes, and is repairable. The design should be such that the lighting system can be integral to soft shelter systems and capable of being easily folded with the shelter for transport. It will not require set-up or installation during deployment. Fabrication methods must be taken into account to reduce cost and labor intensity.

PHASE III: There is not a lighting system in existence that can remain integral to a military shelter system. The focus of Phase I and II of this program would be integrating the system into soft shelters for the military. This would prove beneficial to next-generation systems such as Future Medical Shelter Systems and the Expeditionary Collective Protection System as well as existing systems such as the Chemical and Biological Protected Shelter Systems and Collective Protected Deployable Medical Shelter Systems. This advanced lighting system could be applied to rigid-wall shelters as well as soft shelters across all divisions of the military. The technology could be used to provide advanced lighting to commercial industries such as homeland defense, camping, and transportation.

REFERENCES:
Note: Web site includes links to all aspects of solid state lighting.
2) www.led.net
3) www.lumileds.com
KEYWORDS: lighting, solid state lighting, LED, semiconductor, diode, shelters, tents

A04-215 TITLE: Novel Conductive Fibers for Multi-Path Power/Data Transfer Embedded in Textile Substrates of Warrior Clothing & Equipment

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Fully integrate a wearable multi-path conductive network, for data and power transfer, into Warrior clothing and/or equipment using technologies such as novel conductive textile fibers or printed conductive inks that provide for electrical conductivity and maintain physical textile properties.

DESCRIPTION: Current technology for data/power transfer around the body consists of hanging wires/cables/connectors on the soldier and strategically covering them with other soldier equipment. Some attempts to integrate the wires into narrow woven fabrics and other textiles substrates have been successful but these networks only provide point-to-point transmission. If a break in the network occurs due to cutting the transmission line devices will not function. This SBIR topic looks to explore novel ways of providing multi-path transmission of power and data within a textile based network. This will provide for redundancy of the network so that electronic devices will still functions if there is a localized break in the network. Intelligent detection of a break in a portion of the network should prompt the system to transmit though alternative routes in the system in support of the damaged portion. The network should also allow for power hook-ups for external devices at multiple points on the fabric substrate. Electrical requirements are consistent with commercial cabling such as USB and Fire Wire. Physical requirements should be similar to textile materials used in combat clothing. It is expected that proposals will explore the use of conductive and optical fibers so that physical textile properties are maintained.

PHASE I: Survey a variety of technologies regarding conductive materials with a large variation of physical properties. Select suitable technologies that can be integrated into textile materials to provide multi-path conductivity. The basic technology components for establishing a multi-path conductive network in soldier clothing will be established. Demonstrate several novel technologies such as conductive fibers or conductive ink printing that provide multi-path conductivity and physical textile properties for use in the transfer of data and power in a wearable for Warrior clothing and/or equipment. Describe and detail multi-path (redundant) connection capabilities of the network. The technical feasibility to integrate the technologies into Warrior clothing systems will be established by showing methods, designs, and analysis on how the materials can be integrated. The most effective designs and materials will be determined and proposed for Phase II efforts. The Phase I will achieve Technology Readiness Level 4 (TRL-4).

PHASE II: Fully integrate selected technologies into Warrior clothing providing a multi-path network. Demonstrate working prototypes of network by connecting electronics (computer, batteries, displays, etc.) of the OFW or similar military systems. The contractor will provide 2 working prototypes of textile based clothing items with selected conductive technologies (at least 2 technologies) for a multi-path network. Prototypes shall be tested in a suitable controlled environment. All research, development and prototype designs shall be documented with a detailed descriptions and specifications of the materials, designs, processes, and performance. The Phase II will achieve TRL-5.

PHASE III DUAL USE APPLICATIONS: Textile based multi-path network can be applied to commercial products in the fields of wearable computers or physical/medical monitoring. Applications include multi-path
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network connections for firefighters, police, and first responders, for specific applications. Company shall align with consumer product wearable computer specialty markets and industrial protective services for production of multi-path network products. Commercial wear prototypes shall be capable of being tested in a simulated operational environment. The Phase III will achieve TRL 6.

REFERENCES:

KEYWORDS: Textiles, Fibers, Conductive, Wearable, Computers, Networks, and Fabric

A04-216  TITLE: Computer Input Devices and Embedded Sensors in Future Warrior Handwear (Gloves)

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design and prototype an active computer input device with embedded sensors integrated into handwear (glove) configuration for future soldier systems.

DESCRIPTION: Current Land Warrior soldier equipment provides for a computer input device in the form of a box hung off the soldier’s load carriage equipment. The soldier control unit (SCU) box provides input to computer controls by pressing push buttons in various sequences to perform such inputs as mouse location, select-on, select-off, etc. An input device in a glove form will provide for greater flexibility and additional sequencing due to the availability of at least 5 input sites and additional input positions. The soldier will be able to maintain a choice hand position while inputting and searching information within his computer/information system without having to reach for an external device. It is anticipated that a variety of sensors (i.e. galvanic skin response, magnetic, roller, optical, flex, pressure, etc.) could be located in Soldier’s handware for sensing movement to input signals to a computer. Novel sensor concepts as well as current sensor technology should be considered for this application. A possible secondary application is sensing environmental conditions (i.e., ph, wind speed & direction, laser range finder). Although computers are still external, in the form of laptop and handheld systems, more emphasis is being placed on body conformal systems with an unobtrusive human interface. External input/output devices such as keyboards, touch pads, mouse/pointers, and displays will progressively become more integrated into clothing and eyewear leading to greater demands in the commercial market.

Technical risk lies in the material integration barriers. This device will have all the qualities of a glove as well as those of a computer input device. Material integration barriers to sensor integration will be flexibility of the electrical conduction devices, durability of sensors, fabrics, and networks during use as well as laundering, networking to create more than one conduction path in case of breakage of the glove, integration of the sensor and network devices into a thin textile based material that will allow moisture transport, flexibility, and protection of the Soldier’s hands from environmental conditions such as cold, wind, or rain, and connection of the devices in the glove to the Soldier’s computer. Conduction materials will have to be placed correctly to withstand bending forces caused by the fingers within the glove. Durability of composite materials could be an issue as a result of mechanical deformation, soap, or other substances present during laundering. Gloves have to also withstand impacts and ripping or tearing forces during use. Connection of the devices incorporated in the glove to the Soldier’s personal computer will be a big challenge because the glove is normally a completely separate item from the rest of the garment. Thus the connection path for this item will have to be created. It is perceived that electrical/electronic engineers, materials engineers, and textile technologists will be needed to complement the specific disciplines and to perfect a prototype device that can transmit signals and function as a protective handwear item.

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PHASE I: Select suitable technologies (current and novel concepts) that can be integrated into textile based handwear for multipurpose data input and possible environmental sensing. Demonstrate and provide pre-prototype material components and input devices/sensors. Provide methods of integration and proof-of-concept that the devices can be integrated into a fully functional hardware item. The technical feasibility to integrate the technologies into several Soldier hardware systems will be established by showing methods, designs, and analysis on how the materials can be integrated. The most effective designs and materials will be determined and proposed for Phase II efforts. Phase I will achieve Technology Readiness Level 4 (TRL-4).

PHASE II: Integrate technology components for computer input devices and sensors into soldier hardware. Fabricate and perfect a fully functional prototype computer input device with integrated sensors. All research, development and prototype designs shall be documented with detailed descriptions and specifications of the materials, designs, processes, and performance. Phase II will achieve TRL-5.

PHASE III DUAL USE APPLICATIONS: A commercial application in the area of personnel wearable computers is anticipated. Other industrial and protection services (police, firefighters, first responders) are expected to benefit. Align with consumer product wearable computer specialty markets and industrial protective services for production of input device handware. Commercial wear prototypes shall be capable of being tested in a simulated operational environment. Phase III will achieve TRL 6.

REFERENCES:

KEYWORDS: Keywords: Wearables, Computers, Input Devices, Sensors, Textiles, Gloves

A04-217 TITLE: Anti-Personnel Blast Mine Protection

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To research and develop lightweight material systems that will provide Anti-Personnel blast mine, in stride, combat footwear technology with protection against a minimum of a 75 gram C4 equivalent anti-personnel mine blast. Protection against 100 and 150 grams of C4 is desired.

DESCRIPTION: Current blast protective combat footwear for de-miners who operate at 20 feet per minute, only provides limited protection against small (25gm C4 equivalent) Anti-Personnel (AP) blast mines. Higher protection levels are desired to enable early entry, combat troops keep pace with higher-level threat AP mines concealed in the battle space. The recent research accomplishment of a test methodology that objectively evaluates blast forces exerted on lower limbs and the relating of those forces to expected injuries in humans, now enables the potential application development of improved Anti-Personnel mine blast protection for rapidly advancing combat soldiers.

PHASE I: Research, evaluate and optimize energy absorbing and deflecting material systems capable of being incorporated into combat footwear to provide the greatest degree of AP mine blast attenuation at the lightest weight possible. Team with University researchers for dynamic testing of proposed materials concept samples. Dynamically test concept samples at AP mine blast pressure wave velocities and provide relevant data and graphs relating potential blast overpressure reduction and deflection to the lower limbs from standardized, simulated mines containing from 75 grams of C4 up to 150 grams of C4 as per references.
PHASE II: Team with industry partners to optimize the incorporation of the jointly selected material system into potential protective devices utilizing mutually agreed upon advanced fabrication techniques. Produce a statistically significant number of prototype items for dynamic evaluation of their performance against standardized, simulated mines containing from 75 grams of C4 up to 150 grams of C4 as per references.

PHASE III DUAL USE APPLICATIONS: Produce 10 pair of ergonomically acceptable, size medium items for AP mine blast testing at Aberdeen Test Center (ATC) or other establishment with a test device meeting the requirements of reference 2 below. Based on test results, modify material systems as necessary to optimize blast energy deflection and reduction to the point that there will be a lower limb injury force rating equivalent to 1 (Closed injury, Salvageable limb) or better of the Mine Trauma Score System against the mutually agreed upon maximum level of C4. Produce up to 10 pair of additional, ergonomically acceptable, improved items for verification testing at ATC. Establish performance criteria to enable Anti-Personnel blast mine protective foot wear to be commercially manufactured for both US military and world wide Humanitarian de-mining needs. Develop and provide performance specifications to enable competitive manufacturing of the protective footwear. Demonstrate and provide up to 100 pair of pilot lot quantities of size medium, blast protective footwear made to the approved and certified performance requirements.

REFERENCES:
3) Development of a Test Methodology for Assessing the performance of mine Protective Footwear, University of Virginia Center for Applied Biomechanics, September 2003 (Draft).

KEYWORDS: combat footwear, protection, anti-personnel blast mine protection.
PHASE II: Design, fabricate and test prototype scale device or components under conditions which simulate realistic targets and velocities of interest. Demonstrate applicability to selected military and commercial applications.

PHASE III: The reactive materials will improve the lethality of interceptors with equivalent or lower costs and this would be the result of successful development. This technology is also important to the commercial industry such as demolition and blasting, fusible links for electrical circuit protection, combustible structures, cutting torches, etc.

REFERENCES:

KEYWORDS: Nanomaterials, lethality, reactive materials, munitions

A04-219 TITLE: Advanced Guidance, Navigation and Control (GNC) Algorithm Development to Enhance the Lethality of Interceptors Against Maneuvering Targets

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Air Space and Missile Defense

OBJECTIVE: Develop and demonstrate advanced GNC algorithms (estimators, guidance laws, controllers) for kinetic kill interceptors against advanced maneuvering threats. The advanced GNC algorithms will substantially increase the intercept accuracy against highly maneuvering targets while minimizing the interceptor divert acceleration and delta-v requirements.

DESCRIPTION: The theoretical basis for current GNC algorithms implemented in interceptors has evolved from linear optimal control theory, which includes simple target maneuvers. These implementations suffer from lack of robustness when future threat target maneuvers are encountered, since the interceptor to target maneuver advantage required will exceed the maximums achievable. The spiraling and chaotic nature of ballistic targets in the atmosphere will also stress current GNC capabilities to derive and execute a maneuver fast enough and accurately enough to effect a direct hit.

Advanced GNC algorithm development is essential and is needed for meeting lethality requirements against future advanced maneuvering threats, and also for defining future interceptor concepts and associated critical enabling technologies.

PHASE I: Develop robust interceptor GNC algorithms (to include controllers, estimators, guidance laws) that will provide a higher probability of kill against highly maneuvering threats. Performance goals include: the minimization of the intercept-to-target maneuver, miss distance, and reliance on a priori data.

PHASE II: Optimize results of Phase I, evaluate and mature algorithms developed in Phase I in a 6-DOF test bed, and validate the algorithms in real time hardware in the loop facilities.

PHASE III: Advanced non-linear GNC algorithm development has applications in the commercial airline industry, unmanned aerial vehicles, robotics, rotorcrafts, etc.

REFERENCES:
A04-220  TITLE: Passive, Active Stokes Polarization Imaging System

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO Air Space and Missile Defense

OBJECTIVE: Develop enabling technologies towards a passive or active polarimetric imaging sensor operating in Mid Wave Infrared (MWIR), and/or Long Wave Infrared (LWIR) spectral bands

DESCRIPTION: The target detection and discrimination mission requires sensors capable of target detection, cueing, target discrimination, aim point selection, penetration of battlefield obscurants, and kill assessment. One promising approach for addressing these requirements is in the detection, processing, and evaluation of polarization imagery. Imagery from the polarization properties of radiation emitted and reflected in the short wave, mid-wave and long wave IR has shown potential for improved target discrimination over other IR imaging techniques.

Development of an integrated optical imaging polarimeter requires consideration of optical polarization detection hardware in which the polarization state at each pixel in an image is determined. Previous experimental systems have required long data acquisition times resulting in artifacts in the polarization signature due to changes in the scene. Additionally, calibration and investigation of systematic errors in these systems is difficult and robust calibration procedures have not been fully demonstrated. Proper calibration requires thorough understanding of polarized light and its interaction with materials, polarimetric analysis tools for imaging polarimetric systems, and properties of the polarization critical optical components in the polarization imagers. Therefore this SBIR topic calls for the investigation of novel imaging polarimeter concepts that measure some or all of the polarization parameters and address advanced sensor requirements for speed and sensitivity. For deployed systems, optical and electronic components should be simple and compact, and processing algorithms should be suitable for implementation in onboard processors. Integration of polarization optics and processing circuitry components onto the detector plane is desirable.

The proposed polarimetric system must be compatible with existing sensors and the impact of adding polarization capability should be minimized. An infrared polarimetric imager should be able to produce at a minimum the degree of linear polarization and orientation at 30 Hz frame rates with formats of at least 256 by 256 pixels. Data acquisition of all raw data required to produce polarimetric information should happen simultaneously with minimal spatial misregistration. The goal for spatial registration should be better than 1/10 of a pixel. Moving parts and high voltage requirements are discouraged. Development of algorithms that exploit the data to provide additional information over conventional intensity information such as target cueing, or discrimination capability is encouraged.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of advanced polarization technologies. Special attention should be placed in minimization of moving parts required, frame rate, and light captured.

PHASE II: Fabricate a prototype that demonstrates capabilities defined during Phase I and demonstrate sensor in a laboratory environment and finally with field tests against static and moving objects of interest.

PHASE III: Integrate and produce polarization imaging systems for insertion into air and space sensor platforms and interceptor systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial market for spectral-polarization imaging devices is significant. Commercial application areas include vegetation mapping in agriculture, environmental monitoring such as pollution, geological surveys, medical diagnostics, process and quality control monitoring, robotics, forestry, etc.
A04-221    TITLE: High Power Microwaves

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Air Space and Missile Defense

OBJECTIVE: The objectives of this effort are to develop enhanced explosive and pulsed power for medium caliber munitions (40-mm to 155-mm) and/or critical technologies that support their development. These capabilities would be achieved by adding a directed energy capability or by using new advanced explosive/reactive materials to existing delivery systems.

DESCRIPTION: The radius of damage and the destructive power of conventional munitions is limited to that of the blast and fragments. The objectives of this effort are to extend the lethal range of munitions, increase the scope of the target set, and enhance destruction capability. A directed energy component, such as high power microwave or ultra wideband signals or lasers can attack sensitive electronics and may have longer lethal ranges than blast waves and fragments. Reactive and thermobaric materials can enhance conventional munitions by adding a component that can provide new sensor blinding and power system disruption mechanisms to enhance lethal damage to targets.

PHASE I: Identify potential technologies and analyze, design, and conduct proof-of-principle demonstrations to:
1) verify that the output is predictable and is consistent with predictions and 2) to assess effects on various targets.

PHASE II: Design, build, and test enhanced prototype munitions and/or critical components and verify their capabilities under field conditions. Design production process for mass production.

PHASE III DUAL USE APPLICATIONS: The RF technologies developed under this effort could be applicable to multiple military and commercial applications requiring pulsed power. These include water purification units, nondestructive testing systems, magnetic resonant imaging systems, and lightning simulators. The explosive systems could be used for oil and mineral exploration.

REFERENCES:

KEYWORDS: Munitions, Pulsed Power, Marx Generators, Magnetocumulative Generators, Magnetic Flux Generators, High Power Microwaves, Ultra Wideband, Hot Reactive Metals

A04-222 TITLE: Low Cost Wide Field of View Head Mounted Display for Aviation Training

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO STRI; PM CATT

OBJECTIVE: Develop a low cost, wide field of view and lightweight helmet mounted display (HMD) capable of simple attachment and detachment to aviator helmets (CH-47, UH-60, AH-64A, AH-64D).

DESCRIPTION: Current HMDs are mounted on generic helmets, requiring pads and air bladders to achieve a reasonable fit. Aviators complain of discomfort due to fit and weight, resulting in reduced training time.

PHASE I: Provide an innovative concept that has high resolution light weight optics that can be easily attached and removed from aviator helmets without modification to the helmets. The design concept should meet or exceed existing capabilities of overall weight of helmet and optics of less than 5 pounds; ability to display XVGA data for a resolution of at least 1024 by 768. Provide a field of view of at least 100 degrees horizontal by 50 degrees vertical. The Phase 1 work effort will provide the research team with a better understanding of the design constraints associated with building such a system. The goal of this effort is to prove the concept feasibility and determine the engineering challenges to be faced in Phase 2 when building a prototype. Engineering challenges include deployability, brightness, field of view, and ergonomics issues.
Candidate microdisplay technologies must be examined with tradeoffs considered. A suitable optics solution will have to be researched to meet the required field of view parameters. A strategy will have to be formed for mechanically housing the optics and mounting it to military headgear, considering size and weight factors. Electronics must be researched to drive the microdisplays, and research is required to ensure proper power while minimizing size and weight parameters.

PHASE II: Prototype solution that can be demonstrated on existing virtual equipment (for example the Aviation Combined Arms Tactical Trainer (AVCATT) type manned module).

PHASE III: Develop and market the application to military and civilian organizations with a need for virtual training using visor technology. This would include entertainment industry theme park equipment and the game industry.

REFERENCES:
A04-223

TITLE: Distributed and Collaborative Information Environment for Embedded After Action Review Technologies

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM ONESAF

OBJECTIVE: Develop concepts and technologies for embedding After Action Review (AAR) capabilities to enable Army Transformation.

DESCRIPTION: Today’s fielded AAR systems typically have dedicated production facilities and a theater to present the AAR to the trainees. In the future, a common AAR is envisioned for both mounted and dismounted forces for use in real-world operations as well as training and mission rehearsal. Future forces will have training fully embedded in their vehicles or equipment so that the same operational systems that go to war will also support, and possibly be stimulated by an embedded AAR. This future direction demands technologies that allow commanders in the field to compose useful AARs and Mission Rehearsal sessions using intelligent agents that streamline the AAR development process and allow them to effectively conduct the session within the limitations of their embedded training systems on the operational equipment. In addition, the AAR must support distributed & collective exercises while supporting more operational areas than any past AAR system. The Future Combat System (FCS) Lead Systems Integrator (LSI) has identified embedded AAR as an area that does not have a firm solution and investigation on ways to resolve this would be of great value.

PHASE I: Design a concept and algorithms for embedding AAR within the limitations of an operational vehicle that can distribute AAR within a unit or other multi-player environment to mounted and dismounted players who have embedded training systems. Design a proof of concept for intelligent agents that streamline the commander’s development of the AAR session. Perform an analysis on current AAR systems and capabilities in regards to handling the combination of live, virtual and constructive exercises involving both mounted and dismounted forces. Identify concepts and methods for presenting AAR results within the vehicle using the Army’s digitized equipment. The completion of Phase I will define a system design and architecture to be implemented and include the logic behind selection, technical and behavioral challenges to be addressed, algorithms, and planned approach for implementation.

PHASE II: Using the results from Phase I, develop and demonstrate a prototype embedded AAR system. This concept could be demonstrated using embedded developmental testbed.

PHASE III DUAL USE APPLICATIONS: A possible dual use application would include a distributed gaming AAR within a Massively Multiplayer Environment.

REFERENCES:

NOTE: go to ARI Website for many of these references http://www.ari.army.mil/

KEYWORDS: embedded, simulation, After Action Review, distributed, agent-based

A04-224 TITLE: Visual Aid for Multi Resolution Federation Planning and Development

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Project Manager Constructive Simulation (PM CS)

OBJECTIVE: Produce a generic tool to aid in the identification, visualization, comparison, and ultimately alignment of both simulation and C4I system data. The tool will enable better overall comprehension of modeling disparities amongst a federation of varying resolution simulations as well as differences in the relevant data representation between Multi Resolution Simulation Federates and Command, Control, Communications, Computers, and Intelligence (C4I) Systems, leading to more informed federation development decisions.

DESCRIPTION: Individual federate modeling data that ultimately determine the range of possibilities for Federation Development Execution and Planning (FEDEP) decisions generally lie deep within the bowels of their respective simulations or C4I systems with which they are to interoperate. Bringing this data to the forefront to be viewed and visually aligned with graphical tools allows FEDEP participants from Engineers to Simulation Users to thoroughly understand the variance in modeling and data among federates and thus make better federation, i.e., the Federation Object Model (FOM) development decisions. Currently there exists a wide range of tools that are intended to assist and automate the FOM development process but they generally assume that individual model data is known, available and understood to the degree necessary to make sound FOM decisions. What is needed is an environment to capture relevant data on individual models operating at varying levels of resolution, organize this data into logical groupings as well as allow for its visualization, manipulation and eventual mapping to FOM objects and interactions in real time during the FEDEP process. Prevalent data modeling techniques (Integrated Definition Model Methodology (IDEF), Unified Modeling Language (UML) etc.) are not intuitive enough to use as an effective tool in this case since simulation Users and User Representatives are not generally accustomed to conventional data modeling/abstraction techniques and struggle to gain an intuitive understanding of data relationships presented in these formats. Through FOM decisions should usually be well understood by Users and User Representatives, this need is even further magnified in Multi-Resolution federations such as WARSIM and OneSAF, i.e., those involving aggregate vs. entity level modeling. Additionally, federation decisions in the multi resolution federations also need to consider C4I system data and thus it is also an objective of this effort to include C4I data on the visualization palette.

PHASE I: This research effort will identify a multi-resolution federation, e.g. the Army Constructive Training Federation (ACTF), and collect multi-resolution model data in the area of Force and Command Structure and basic Combat and Attrition for relevant simulations and C4I systems. In parallel, techniques will be researched and chosen to be incorporated into a data visualization aid to present and manipulate data to the broad range of FEDEP participants. This phase will provide a design concept.

PHASE II: The goal of the Phase II effort is to evolve the prototypes produced in Phase I into functioning data visualization and manipulation components and integrate them into a functioning system. Concurrently, the data content of the tool will be expanded to include representation of logistics and supply data as well as side and faction data. The second phase will result in the demonstration and use of this data visualization tool in the FEDEP process for an appropriate Multi Resolution federation, e.g., the ACTF linkage of OneSAF and WARSIM or the linkage of JDLM with CBS and JCATS. Linkage to C4I systems, such as the ABCS, will be required as part of these
simulation linkage efforts. The ACTF Program will sponsor the federation of many models and C4I systems operating at varying levels of resolution over the next four years, so there will be an abundance of opportunities to provide a relevant demonstration of the Phase II capability.

PHASE III DUAL USE APPLICATIONS: Data alignment issues encountered in DoD linkage of Multi-Resolution simulations can be considered more a specific case of a data alignment problem. Any visualization tool that can be developed to give the non-developer insight into the various possible alignment combinations of disparate data from heterogeneous systems can result in better coordinated and user-understood design decisions. It is not just military simulations that have a need for a broader understanding, through visual depiction, of the relationship between data that supports linking two or more information systems at varying levels of resolution. This problem is so widespread in the commercial sector that dual-use possibilities could be considered nearly endless.

REFERENCES:
4) Bauers, Andrew; Prochnow, Dave; Roberts, Jonathan; (fall 2002), JTLS-JCASTS, Design of a Multi Resolution Federation for Multi-Level Training. Fall 2002 SIW-034.
5) Bauers, Andrew; Prochnow, Dave; (Fall 2003), Multi Resolution Modeling in a JTLS-JCATS Federation, Fall 2003 SIW-067.

KEYWORDS: Federation Development, Execution and Planning, Multi Resolution Modeling, Data Alignment, C4I


TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO STRI/PM ITTS Targets Management Office

KEY TECHNOLOGY AREA: Advanced Materials and Manufacturing

OBJECTIVE: The objective of this effort is to research advanced manufacturing technologies that improve Army capabilities by providing light weight, low-cost, high-fidelity targets and surrogate vehicles for use in gunnery training and sensor testing.

BACKGROUND: The targets currently used on military gunnery ranges most often consist of plywood cutouts with simplistic heating elements that represent the general shape, size, and thermal cues of threat vehicles. While these targets certainly provide visual and thermal stimuli to gunners to exercise their weapon systems, they provide little in the way of threat representative visual and infrared signatures. Sensor operators need to be provided with proper visual and thermal signatures during training so that they can more accurately perform combat identification tasks on the battlefield. Gunnery targets that provide improved representations of the shape, environmental interactions, and thermal signatures of threat vehicles would enhance the training state-of-the-art for gunners and sensor operators.

DESCRIPTION: The extreme lethality of modern weapon systems makes it critical that gunners and sensor operators be able to properly identify targets to maximize the impact of their weapons on the battlefield while simultaneously avoiding fratricide incidents. Current gunnery targets used on training ranges involves the use of locally fabricated targets with only rudimentary signature enhancements. The goals of this effort will be to investigate advanced materials, and manufacturing technologies for creating gunnery training targets that are highly representative of potential threats that will be encountered on a battlefield. The manufacturing technologies and materials to be investigated in this effort must demonstrate that it is feasible to produce targets that are (1)
geometrically accurate and target representative to both visual and thermal sensors, (2) significant advances over the current state-of-the-art in signature fidelity, (3) affordable, (4) light weight, and (5) easy to assemble and dismantle.

In addition to gunnery training targets, this effort will also address the development of targets to augment or possibly replace actual vehicles used in sensor testing. Target surrogates and the materials designed and developed in this phase of the effort will be required to emulate the visual and infrared signatures of an actual vehicle under all weather and operational conditions without requiring constant user inputs or extensive maintenance. These target surrogates could potentially be full-scale or sub-scale and the material development and target designs should accommodate for any possible scale.

TECHNICAL RISK: The research, development and technical risk for this program is low. Previous surrogate development efforts involving lightweight materials and signature augmentation devices have been successfully performed in support of various Government agencies.

PHASE I: Develop concept designs for multi-spectral targets for both gunnery training and sensor testing that demonstrate a significant signature fidelity improvement over the current state-of-the-art.

PHASE II: Develop detailed designs, determine optimum manufacturing methods, and fabricate prototypes of the concept designs developed in Phase I and develop signature validation plans for the new designs.

PHASE III DUAL USE APPLICATIONS: Dual Use Applications: The targets developed under this effort will have applications in the training of law enforcement and homeland security personnel. Thermal sensors play an increasingly important role in law enforcement and border security and the technologies developed under this effort will be able to be used for the development of law enforcement training systems. Commercial potentials for the technologies developed under this SBIR include the manufacturing of training systems for existing gunnery ranges and law enforcement as well as training and test targets for weapon systems currently under development such as Unit of Action (formerly the FCS Office).

REFERENCES:

KEYWORDS: gunnery targets, infrared signature, target surrogate, multi-spectral targets, gunnery training, manufacturing technologies
DESCRIPTION: Tactical decision making often involves high levels of ambiguity. Army leaders in the Future Force will be forced to make rapid decisions based on a variety of information, some of which might be contradictory. One method of training such decision-making skills is through the use of vignettes, or short story scenarios. The vast majority of tactical leader training involves developing and/or refining decision-making skills in a near real-time environment (Live, Virtual, or Constructive). The use of computer-based Real-Time Story training is becoming widespread throughout the military for institutional, home station, and web-based training. This topic seeks to extend the state of the art in the use of Intelligent Agents to enhance cognitive training for developing decision-making skills in areas involving high levels of ambiguity by adapting stories in real-time to tailor them to individual needs. Furthermore, the intelligent agent will incorporate performance feedback for individualized, focused training and remediation. (There will also be application for story-training developers to use the tool for assessing initial training if there is a skills baseline derived from a pre-course survey/assessment.) The results of this research will enhance story-oriented training events to offer personalized training and remediation that is focused on the individuals needs. The lessons learned from this research will be invaluable in developing more sophisticated instructional aids for all classroom and web-based cognition training. This topic is focused on the technology required to produce an intelligent agent capable of Real-Time Adaptation of Stories for training along with accurate assessment and focused remediation.

PHASE I: Phase I research efforts may include exploration of how vignettes, or short, focused, story-oriented training scenarios can be integrated into distance learning environments to provide leader development training for training areas with high levels of ambiguity. Exploration areas could focus on any “ambiguous” tactical situation/scenario that includes decision-making for leaders and/or staffs. Intelligent agents should assist tactical instruction through individualized assessment, feedback, and training. Phase I may include survey/examination of existing development tools, assessment tools, and other technologies that can be leveraged for Real-Time Adaptation of Stories for training.

The projected outcome of Phase I will be a research report based on the findings from Phase I research, as well as a plan for a prototype to be delivered during Phase II.

PHASE II: Phase II research efforts may include adapting/leveraging intelligent agents that provide individual assessment and feedback for focused student remediation to demonstrate the ability to develop story-based training vignettes that focus on high order tactical decision-making skills with high levels of ambiguity.

The Phase II deliverables will be a demonstration of the intelligent assessment capability and a detailed research report.

PHASE III DUAL USE APPLICATIONS: In Phase III, it is anticipated the successful bidder will be able to apply the same technologies developed in Phases I & II to building a commercially-marketable assessment tool. Potential customers include all branches of the U.S. Armed Forces and law enforcement organizations at various levels.

REFERENCES:
1) Pliske, R. M., McCloskey, M. J., & Klein, G., Decision skills training: facilitating learning from experience, In E. Salas @ G. Klein (Eds.), Linking expertise and naturalistic decision making, pp 37-53, Mahwah, NJ: Lawrence Erlbaum Associates
2) Magerko, B., & Laird, J., Towards building an interactive, scenario-based training simulator, University of Michigan

KEYWORDS: assessment, vignette, training, remediation, intelligent agents
TITLE: Innovative Wireless Network Modeling And Simulation Technology In Support of Training, Testing And Range Instrumentation Requirements

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO STRI/ PM ITTS

OBJECTIVE: The purpose of this SBIR is to research, investigate, model and design a robust, secure, and reliable integrated broadband wireless network to support the emerging weapon system Range Instrumentation's testing and training needs.

DESCRIPTION: Within the Range Instrumentation community, Range Digitization efforts are underway to upgrade the strategic telecommunication infrastructure of the test and training ranges to provide them with the necessary bandwidth and technology in support of the ever increasing demands in their networks. The technology upgrades have been primarily focusing on the “hard-wire” digitization of the ranges with the installation of optical fiber, transmission electronics and network management systems to support the backbone infrastructure. White Sands Missile Range Test Support Network (WSMR-TSN) and Yuma Proving Ground Range Digital Transmission System (YPG-RDTS) have been leading the digitization efforts and technology upgrades for the Army Test and Training ranges. To complement these Range Digitization efforts, a complementary communications modeling & simulation (M&S) effort was initiated during the FY99 – 00 time-frame which has resulted in a robust, predictive range communications network model deployed during FY03 to White Sands Missile Range that will properly forecast the necessary ‘hard-wire’ bandwidth for the transport of high data rate applications, such as voice, telemetry, streaming video, imagery, and other bandwidth intensive applications in real time. (End user access to this network is primarily done through digital and analog interfaces and many are wireless connections.) It is expected that the upgrades in the fixed, “hard-wire” range communication network infrastructure will benefit remote users having a wide range of wireless applications, for instance, wireless point-to-point data and multicast wireless data transport. The goal of this SBIR topic is to investigate the feasibility of modeling a high speed digital wireless networking environment that can be integrated with the fixed, “hard-wire” range communication network infrastructure. The complementary range wireless network would leverage on the latest Wireless technologies such as Bluetooth, HomeRF, the IEEE 802.11b and other emerging wireless technologies. The modeling of the integrated environment will allow the study and analysis of the various wireless applications, and protocol development for same. Specifically, this research and development effort will focus on developing the appropriate high speed digital and wireless access points (WAP) to the “hard-wired” network or fixed communication infrastructure for wireless connectivity, dynamic allocation of bandwidth, multimedia traffic delivery, voice, and data call hand-off management. The WAP will provide the required multi-protocol functionality for secure and reliable communications between geographically dispersed users. The distance and data rates limitations imposed on the current Wireless networking technologies and protocols, and other wireless network issues pertaining to high-speed multimedia data transport would be thoroughly investigated. The ultimate goal will be to develop an innovative wireless range networking environment that can be easily integrated with a fixed, “hard-wired” network communication infrastructure. This wireless network should be capable at operating effectively in any test or training range environment, hostile environment, and in a variety of terrain conditions. This innovative technology will ultimately support the Army Transformation efforts for the 21st century.

PHASE I: Investigate the latest wireless technologies available in the market, and research on the feasibility, and practicability of developing innovative Wireless Access Points (WAP), wireless network model and an integrated network architecture, capable of transporting high speed multimedia data rates in real time. This network should be capable of interfacing with a fixed, “hard-wire” network infrastructure, and/or command control center to extend its range of transmission and operation. Also investigate and report on the technical issues pertaining to wireless transmission of digital high-speed multimedia data, and use modeling and simulation to assess and analyze this information.

PHASE II: Apply the phase I research results and simulation analysis and construct/validate a prototype model for a wireless range network; consisting of the proposed high speed digital interfaces or wireless access points. Interface
of this wireless network prototype to the fixed, “hard-wire” network infrastructure can be demonstrated using WSMR-TSN or YUMA-RDTS test ranges as a test bed.

PHASE III DUAL USE APPLICATIONS: The Phase III of this effort will leverage on the results of Phase II's technological demonstration and network model software prototype to incorporate this technology in the Department of Defense transmissions systems to include all the range communication systems and networks. The resulting technology should have the potential for dual use application to include the commercial sector's applications. It is expected that, during this phase, the prototype developed under phase will result into full production that would benefit the Test and Evaluation, Training, in support of the Future Combat System and Objective Force. This technology, once mature, would have potential commercial applications, such as the wireless Internet, wireless local area networks (LAN), intelligent transport systems (ITS), and broadband wireless access.

REFERENCES:
1) IEEE Standard for Information Technology-Telecommunications and Information exchange between systems-Local and metropolitan area networks- Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC), and Physical Layer (PHY) specifications; Amendment 2: Higher-Speed Physical Layer (PHY) extension in the 2.4 GHz band-November 2001.
2) A. Kamerman, Coexistence between Bluetooth and IEEE 802.11 CCK Solutions to Avoid Mutual Interference, Lucent Technologies Bell Laboratories, January 1999.
3) Broadband Radio Access Networks (BRAN), High Performance Radio Local Area Networks (HIPERLAN) type2, ETR0230002 v.0.2.0, 1999-2004
4) K. Mitchell, K.Sohraby, An analysis of the Effects of Mobility on Bandwidth Allocation Strategies in Multi-Class Cellular Wireless Networks, University of Missouri.

KEYWORDS: telecommunication, multicast, hard-wired network, broadband, digitization, training, testing, simulation, integration, wireless access points, Range Instrumentation, network integration, strategic communications.
The purpose of this SBIR topic is to: 1) determine the technical feasibility of the continuous dynamic magnetic compaction (DMC) for near net-shape SiC green body tile production, 2) determine whether these DMC produced SiC green bodies can be densified, e.g. sintered, to optimize mechanical properties, and 3) establish whether DMC based processing can meet or exceed current cost goals to become a commercially viable ceramic armor tile production method.

Due to fast (sub-millisecond) compaction times, DMC along with automation of filling the die with powder and removing the part has achieved manufacturing rates of six parts per minute. This is a production rate not heretofore imagined for ceramic armor tiles, which employ production processes similar to high temperature resistant brick (refractories).

DMC of the starting powder(s) improves as particle size decreases. Current SiC starting powders are approximately one micron in size, but sources for nano-SiC will be considered and used where feasible. With the fast (sub-millisecond) compaction time, DMC has been shown to be a good processing approach for compacting nano-sized materials. The high green density attained via DMC enables shorter sintering times at lower temperatures with minimum to no grain growth. There is interest in the exploration and development of high performance nano-SiC for armor applications.

PHASE I: The efforts required for Phase I are three-fold and attainable within SBIR time cost constraints; the minimum accomplishments are:

1. Achieve mechanical properties comparable to or exceeding those of SiC-N with a representative data sample; e.g. 30 rectangular bend bars.
2. Develop a viable process concept to produce 4"x 4" tiles, either square or hexagonal.
3. Develop a cost and production volume/rate model for the process concept.

The efforts required for the Option for Phase I are attainable within SBIR time cost constraints; the minimum accomplishment is to produce a design for full-scale manufacturing using DMC for 4"x 4" tiles for ballistic tests.

PHASE II: The efforts required for Phase II are two-fold and attainable within SBIR time cost constraints; the minimum accomplishments are:

1. Confirm the scale-up of the DMC process concept with the cost model.
2. Make 4"x 4" samples for ballistic tests to populate three 3’ x 4’ arrays.
3. Develop suitable proof testing procedures for continuous manufacturing.

PHASE III DUAL USE APPLICATIONS: In Phase III, production will be full-scale and in sufficient quantity to populate a vehicle with control of quality and validation of cost and performance models. In addition to combat and tactical vehicle protection, cheaper silicon carbide tiles in high volume may potentially be of use in refractory furnaces, hot presses, smelting furnaces, space vehicles, armored cars, body armor, and electronic ceramic applications.

REFERENCES:
A04-229  TITLE: Automated Propagation of Design Intent from Legacy Drawings to 3D Models

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To research and develop software to transfer design intelligence from legacy 2D drawings to parametric 3D models.

DESCRIPTION: It is a common feeling in the engineering design community that even though 3D models are excellent for designing new parts, they still lack a lot of engineering/manufacturing knowledge and design intelligence that 2D drawings used to carry. This design intent is usually represented in non-geometric form such as dimensions, constraints, notes on surface finish and material properties, geometric dimensioning and tolerancing (GD&T), fixturing information, etc. Even though today’s sophisticated 3D CAD software allow users to model from scratch in 3D, or provide add-on tools to help migrate 2D drawings to 3D models, this is strictly limited to converting geometry. Typically, the first step in converting a 2D drawing to a 3D model is deleting or turning off layers corresponding to non-geometric entities. This is where the original design intent is lost. Even if the model is now re-created in 3D, the new design intent used may or may not match the original design intent of the designer. Furthermore, the 3D model will also need to have an associative 2D drawing that is generated from the 3D model. This is where most of the notes and other non-geometric information are stored.

With the implementation of a software to automatically or semi-automatically help in transferring design intent from 2D drawings to 3D models, 3D models can be self-standing with no need to store 2D representations. This will allow users to handle a homogeneous data format that contains all the relevant design and engineering intelligence required to manufacture the part. As Army combat vehicle programs gradually migrate their design to 3D, this software will be invaluable in assuring that all the information from legacy drawing are carried over the newer intelligent 3D models. The software implemented after the Phase II effort can potentially be used by all DoD Program Managers that will convert 2D drawings to 3D models for vehicle support and spare parts manufacturing.

PHASE I: Develop design intelligence attributes that are critical for knowledge management. Research the issues and evaluate the feasibility of extracting design intelligence from 2D drawings.

PHASE II: First develop an architecture and strategy to develop the system followed by prototype software development to accomplish the objectives. Demonstrate the prototype using representative test data.

PHASE III DUAL USE APPLICATIONS: This research can potentially be adopted by commercial CAD/CAM vendors to improve their capture and storage of design intelligence and knowledge management.

KEYWORDS: Design intent, knowledge management, spare parts, legacy drawings, parametric models

A04-230  TITLE: Optically Clear Armor Protection

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems

OBJECTIVE: The objective of this SBIR is to develop a capability of using novel lightweight optically clear polymers as armor protection for ground personnel vehicles. Production of clear and lighter systems is possible with new emerging technology. By replacing heavy bullet proof glass or substituting vehicle glass with lighter structural strength transparent polymers the Army will benefit from being able to deploy safer and lighter systems and to give the soldier added protection.
DESCRIPTION: In the initial study, the contractor will identify possible transparent polymer materials with ballistic protection properties meeting or exceeding the threshold requirement for FCS base armor of 14.5 caliber. Of particular interest to the Army is identification of material systems that can be used in military vehicles as lightweight optically clear armor protection. The topic will be coordinated with PM FCS and Survivability office.

PHASE I: During the first phase of this program the contractor will investigate a suitable transparent material for ballistic protection with the focus that in Phase III these materials will be used on DoD's tactical vehicles' windshields and replacing other glass where transparent properties are required. During this phase of this program the contractor will perform a feasibility study of various design possibilities of polymers with ballistic protection properties (i.e. materials that have high energy absorbing properties). The selected polymers will have excellent impact resistance, energy absorbing and thermal properties and have resistance to projectiles meeting or exceeding the requirement for FCS base armor of 14.5 caliber. This feasibility study will culminate in a final report which will identify the potential material candidates that will be manufactured as prototypes and tested in Phase II of the study.

PHASE II: During the second phase of this program the contractor will fabricate and test top candidate solutions from Phase I. In this phase the prototypes will be developed to achieve a particular performance specification. Top candidate prototypes shall be subjected to ballistic field testing. Effects of exposure to heat and flammability shall also be evaluated in the field tests. The proof of technological feasibility and producibility of the top candidate solutions shall be reported. The economics and scalability of the proposed manufacturing technology shall be documented in the final report. Tests that will provide the exit criteria for this determination will be performed on prototypes and include, but are not limited to: structural-properties of candidate designs, threat protection, and heat and flammability resistance.

PHASE III DUAL USE APPLICATIONS: During the third phase the solution candidates can be used in a broad range of military and some civilian applications including any and all of the possibilities listed below: 1) windshields and replacing side and back glass for any tactical vehicle, security vehicles, or personal vehicle, and 2) soldier face shield.

REFERENCES:
1) FCS Operational Requirements Document (ORD). (The specific criteria for survivability is classified secret and it will be offered to the contractor at contract award.)

KEYWORDS: vision protection, clear vision, ballistic protection, energy absorbing optically clear polymers, lightweight, soldier survivability

A04-231 TITLE: Composite Structures for Ballistic Protection

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems

OBJECTIVE: The objective of this SBIR is to develop a capability of using lightweight composite hybrid structures for ballistic protection for tactical ground vehicles. The lighter weight materials will need to provide prescribed protection levels previously achieved with heavier metals. A structure that is rigid yet has flexural strength and ballistic characteristics is possible and can be developed. The production of composite lightweight systems is possible by combining proven and emerging technology. By replacing heavy components with lighter components with blast resistant composite structures the Army and the soldier will benefit from being able to deploy safer and lighter systems.
DESCRIPTION: In the initial study, the contractor will identify possible composite hybrid structures, which can be shaped or formed to fit vehicle contours, with ballistic protection properties that protect against NATO M80 7.62 mm ball rounds and 7.62 mm AP (type to be recommended by contractor) at muzzle velocity. The selected contractor will use lightweight composite material in combination with ceramic, Kevlar, fiberglass, urethanes, etc. Of particular interest to the Army is identification of composite structure systems that can be used in military vehicles as lightweight armor protection. In addition, an attachment method should be developed that allows the armor structure to be easily installed and removed from the vehicle with minimal time and manpower. The armor should also be light enough to allow the use of the current vehicle hardware such as door hinges, suspension components, etc. The topic will be coordinated with the lightweight structures group.

PHASE I: During the first phase of this program the contractor will perform feasibility study of various design possibilities of composite structures with ballistic protection properties which are shaped or formed. The contractor will use lightweight composite material in combination with ceramic, Kevlar, fiberglass, urethanes, etc. for his study. Composite structures will be selected based on the intended application and in coordination with selected manufacturing processes. The selected structures will have excellent impact resistance, energy absorbing and thermal properties and have resistance to projectiles meeting or exceeding the requirement for ballistic protection against NATO M80 7.62 mm ball rounds and 7.62 mm AP (type to be specified by the contractor) at muzzle velocity. This feasibility study will culminate in a final report which will identify the potential composite structure candidates that will be manufactured as prototypes and tested in Phase II of the study.

PHASE II: During the second phase of this program the contractor will fabricate and test one tactical vehicle armor kit from the top candidate of Phase I. The selected recipe to be used must be approved by the COR. The vehicle to be armored will be jointly selected by the COR and contractor. At a minimum, the contractor will be allowed access to the chosen vehicle but not necessarily allowed to attach the armor to the structure. In this phase the composite structure prototypes will be developed to achieve a particular performance specification. Top candidate prototypes shall be subjected to ballistic testing. Effects of prolonged exposure to heat and flammability shall also be evaluated in the field tests. The proof of technological feasibility and producibility of the top candidate solutions shall be reported. The economics and scalability of the proposed manufacturing technology shall be documented in the final report. Tests that will provide the exit criteria for this determination will be performed on prototypes and include, but are not limited to: structural-properties of candidate designs, threat protection, and heat and flammability resistance.

PHASE III DUAL USE APPLICATIONS: During the third phase the solution candidates can be used in a broad range of military applications and some civilian applications, including any and all of the possibilities listed below: 1) FTTS vehicles, FMTV 2) Any tactical vehicle; 3) Security vehicles and shelters.

REFERENCES:
1. NATO Draft Specification STANAG 4569

KEYWORDS: survivability, ballistic protection, lightweight, tactical vehicles.
dependent on the wavelength, the surface properties (index of refraction and surface roughness), external sources, and the geometry of the sensor, the surface, and the sources. In several experimental systems, significant contrast has been demonstrated that complements the conventionally imaged signature. However, these experimental systems frequently require long data acquisition times resulting in artifacts in the polarization signature due to changes in the scene. Many of these experimental systems are also not highly integrated and do not meet stringent volume and power constraints. Additionally, calibration and investigation of systematic errors in these systems is difficult and robust calibration procedures have not been fully demonstrated. Proper calibration requires accurate laboratory instrumentation to characterize the full polarizing properties of the polarization critical optical components in the polarization imagers. Laboratory instrumentation is also required to better characterize target and background materials and understand the variation of polarization signatures with wavelength, geometry, and material property. The goal of this Phase I is to investigate novel imaging polarimeter concepts that measure some or all of the polarization parameters and address Army requirements for speed and sensitivity while simultaneously providing a highly integrated sensor. In addition, this effort will consist of the investigation of the phenomenology that produces polarization signatures, development of calibration devices or procedures for polarization imaging systems, and development of instrumentation that characterizes the polarization properties of materials and critical optical components.

PHASE I: Investigate novel concepts for imaging polarimeters and design laboratory instrumentation for the characterization of polarization properties of materials and optical components.

PHASE II: Produce a prototype of the imaging polarimetric instrumentation and demonstrate the measurement capabilities in appropriate tests. Proper calibration procedures and any necessary calibration hardware should be developed and verified.

PHASE III DUAL USE APPLICATIONS: Multiple military applications include not only advanced seekers for Future Combat Systems (FCS), but also for autonomous guided munitions, UAV’s, mine detection, trip wire detection, and theater missile defense. A wide range of commercial applications can be projected including humanitarian de-mining, ice detection, machine vision, and display technology. The commercial application should be formulated during Phase I. A complete commercialization plan must be completed in Phase II.

REFERENCES:

KEYWORDS: retarders, polarizers, polarimetry, Stokes vector, Stokes parameters, imaging polarimeters, polarization elements, polarization signatures
OBJECTIVE: The objective of this project is to develop a multipurpose MEMS based engine management sensor, to include both hardware and software. The sensor will be able to operate reliably in various locations inside the engine and in any engine types. This sensor must be able to withstand and work under the harsh engine environment. The main task of the sensor has two functions: first, the sensor is used detect engine combustion phenomena to improve engine management regulation and second, the sensor will also have the capability for providing advanced diagnostics to improve health monitoring.

DESCRIPTION: Utilizing commercial software and hardware solutions where applicable, a very small multipurpose MEMS based sensor device can be embedded into various engine compartments to monitor engine functions and performance. The sensor device will be robust enough to withstand the extreme temperature/pressure variations and operating conditions in different parts of the engine compartments. The sensor device shall be design inherently small or micro size to be inserted or embedded without the need for specialized tooling, equipment and/or modification kits. The goal of this sensor is to be able to measure a couple or more environmental parameters consisting of, but not limited to, air flow, fuel flow, temperature, pressure, gas composition, light, wavelength, and other measurable physical environmental parameters. This multipurpose sensor device can be utilized to improve, but not limited to, an engine management and health monitoring system, the efficiency of the engine unit, engine performance, provide information to diagnostic unit, the determination of engine failure, and many other engine functions. This will increase the ability of logistic support, maintainability and readiness.

PHASE I: Develop overall system design to include feasibility study and specification of MEMS technologies that can operate in extremely harsh conditions such as an engine and its various compartments.

PHASE II: Develop and demonstrate a prototype system in a realistic environment to support feasibility study and findings of the Phase I research.

PHASE III DUAL USE APPLICATIONS: This technology has the potential to revolutionize engine management for both the military and commercial applications. The benefits of engine management to the military will improve vehicle performance, reduce maintenance, and improve logistics and engine life. In commercial applications similar benefits, such as improved engine life and better fuel efficiency, will apply. This multipurpose sensor device will be an enhancement to monitoring and possible is used to improve engine performance and maintainability by monitoring specific engine combustion phenomena’s and thus adjusting specific parameters to provide maximum function of the engine.

REFERENCES:
1) The MEMS Handbook; by M. Gad-El-Hak


There are also many references and papers concerning emissions, engine diagnostics, engine performance related issues and telematics at:
www.sae.org
http://www.epa.gov/otaq/
A04-234  

TITLE: Standoff Improvised Explosive Device (IED) Detection System

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Combat Systems

OBJECTIVE: Demonstrate the feasibility of detecting Improvised Explosive Devices (IED) hidden under rocks, concrete, and foliage, at a standoff distance while moving, through the sensor fusion of an impulse ultra-wide band radar with a polarized, 3-dimensional, multi-spectral IR imager.

DESCRIPTION: Improvised Explosive Devices (IED) are devices placed or fabricated in an improvised manner incorporating destructive, lethal, noxious, pyrotechnic, or incendiary chemicals and designed to destroy, incapacitate, harass, or distract. It may incorporate military stores, but is normally devised from nonmilitary components (DOD definition). IEDs are commonly disguised and/or camouflaged to blend in with the environment to which it is deployed making it very difficult to visually discriminate. They can be autonomously detonated through a sensor fuse or remotely command detonated by an individual.

It is only recently that the enabling technologies have become available to make impulse ultra-wide band (UWB) radar and multi-band IR a reality. It is proposed that an impulse ultra-wide band radar be developed that would be optimized for penetrating through natural and man-made non-metallic materials to include rocks, concrete and foliage. Any metallic object, such as a shell casing rigged as an IED, hidden within these materials would generate a strong radar return signal. This radar technology has the benefits of being non-RF intrusive and jam resistant making it compatible for use in urban environments. Because background clutter may generate false positives, it is proposed that a multi-spectral IR imager be developed and sensor fused with the radar to aide in clutter rejection. The spectral bands should be selected to maximize sensitivity to foliage, rocks, sand, and concrete. By subtracting these clutter bands from a normalized thermal band, we may be able to remove the clutter to detect hidden foreign objects. By polarizing the IR receiver, we can further enhance detection of man-made objects such as IEDs. We can also employ 3 dimensional imaging to separate 3-D objects from flat surfaces. A novel algorithm will need to be developed that will synergistically fuse all the sensor data to robustly reveal locations of high probability of a hidden IED.

Although the concept appears straightforward, the implementation is challenging. One of the system requirements is that it must not disrupt current urban infrastructures such as cell phone, TV and radio transmissions. Impulse UWB radar accomplishes this by operating in the noise level. In order to extract the signal from the noise floor, it requires multiple integration of pulses. However, vehicle movement limits the amount of integration that can be performed. This is especially challenging when the material covering the IED is thick, hence requiring a large number of integrations. Hyperspectral imagers that uses filter wheels to scan one band at a time has far too slow of a refresh rate for driving applications. The challenge is to develop a multi-spectral imager that can register multiple IR bands simultaneously and with sufficient sensitivity for driving applications. The probably of detection must be high since a miss can mean life or death. False alarm rate must also be low otherwise the driver would eventually ignore the system alerts. Since IEDs are often disguised as objects that are typical in the environment, it will be quite challenging to develop a robust detection algorithm that can discriminate true targets from clutter. Since the vehicle is moving through potentially different clutter type and frequency environments, the detection algorithm may need to employ fuzzy-logic in order to adapt to the changing environment. All of these challenging issues stress the need for innovative and novel technologies and approaches.

PHASE I: Expect the delivery of a technical report which details various design alternatives with the preferred system concept identified. Include strengths and weaknesses of each design and validate concept through modeling & simulation and laboratory testing. Include detail tasks, risk areas, risk mitigation plan, schedule, list of required hardware and equipment, test plan, integration plan, militarization/ruggidization plan, employment concept, and estimated unit production costs associated with the development and evaluation of your proposed concept.
PHASE II: Expect the development, evaluation and delivery of a prototype system that has demonstrated detection of a 155 mm shell casing hidden under rocks, concrete and tall grass at a 20 m standoff while mounted on a HMMWV moving at 15 kph over primary roads. User interface should include range and direction to suspected IED and an audible alarm. Driver should be able to quickly see information while driving. Deliverables will include a technical report describing phenomenology of how the system works, a technical manual on how to install, operate and employ the system in an operational environment, TTPs, and any models and simulations used in optimizing the design.

PHASE III DUAL USE APPLICATIONS: The technology developed in Phase II will have a growth path to be militarized for type-classified deployment. The technology may also be capable of detecting UXO and mines. The technology may be modifiable for off-route usage.
(a) The technology can potentially be commercialized for detection of irregularities on the road such as pot holes, blown-out tire remnants, and trash for active suspension, collision avoidance, road repair, and trash pickup applications. Technology may also be used by law enforcement, homeland defense, and airport security for detecting suspicious objects in high clutter environments.
(b) DoD may be able to benefit from the commercial maturation of this technology. Mass production of the technology by the automotive industry will result in a smaller, more power efficient, more reliable, and higher performance system at much lower costs.

REFERENCES:
1) http://call.army.mil/, http://www.tswg.gov/tswg/idd/idd_ma.htm,
3) http://www.galaxyscientific.com/areas/securtech/simied.htm,
4) http://www.enterprisingscurities.com/training/search_protocol.html,
5) http://www.respondersafety.com/downloads/standoff.doc


A04-235  TITLE: MEMS Testing Simulator

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM Heavy Tactical Vehicles

OBJECTIVE: The objective of this SBIR Program is to develop a MEMS testing simulator, to include both platform hardware and software. The simulator should be able to provide full environmental and loading conditions of MEMS reliability testing under various simulated and/or accelerated damaging environments, including impact/drop condition of a MEMS device involving a high strain rate. Furthermore, to develop an integrated sensor array that is embedded inside the MEMS package that has a self-diagnostic function. Lastly, to explore the concept of self-recovery of MEMS packaging, and develop first generation self-diagnosis and self-recovery MEMS packaging techniques. Self-diagnosis and self-recovery MEMS packaging techniques such as self-healing composite materials to address microcracking in electronic packaging is to be explored.

DESCRIPTION: MEMS with sensors and actuators in highly integrated circuits, and with intelligent control functions in a large network system, often needs to be working under a harsh environment involving changes in mechanical, chemical, and electromagnetic loading at high frequencies and high intensities. The present packaging technique - the key manufacturing step that provides protections for the environmentally-sensitive MEMS, only addresses initial reliability, but can not provide the insurance and reliability assessment under many extreme conditions such as repeated drop/impact loading of a micro-device (e.g., cell phone or Palm PC), and provide an accurate prediction on functional deterioration and failure, which is critical for a MEMS or a micro-device to be used in a large-scale network that can not tolerate any system failure.
PHASE I: (1) Design and develop a first-version prototype reliability testing platform that allows MEMS and micro-devices to be tested under various simulated and accelerated loading/environment as required; (2) Verify the concept of embedded sensor array inside a MEMS that allows monitoring temperature, internal stress state and dynamic loading, hermeticity and electrical charge; (3) Verify the concept of self-diagnosis and self-recovery functions of MEMS. Some developed key techniques will be patented.

PHASE II: (1) Develop and demonstrate a full-function MEMS testing simulator system in a realistic environment; (2) Conduct experiments on packaging materials and build a new database, and conduct reliability testing of MEMS packaging and micro-devices; (3) Implement the new concept of self-diagnostic and self-recovery function into MEMS packaging and lab MEMS manufacturing; (4) Develop and validate damage models, and develop science-based reliability analysis software that correctly interpret the testing results from this simulator. Through this Phase-II study we will significantly improve the MEMS manufacturing capability by means of: (a) achieving a high initial reliability with increased throughput and success rate during MEMS manufacturing; (b) More reliable service functionality through more accurate reliability testing under wider and more aggressive testing window before product shipping; (c) Extended service life and system reliability through embedded sensor array and with self-diagnosis and self-recovery functions. By the end of Phase-II this technique will be commercial ready.

PHASE III. DUAL USE APPLICATIONS: Open a production line producing the new MEMS simulator systems with hardware, software and technical support. This MEMS testing simulator system could be used in a broad range of military and civilian security applications.

REFERENCES:

KEYWORDS: MEMS testing simulator, self-recovery of MEMS packaging, self-diagnosis and self-recovery MEMS packaging techniques

A04-236 TITLE: Sensor Technology for Materials Characterization aboard the Mobile Parts Hospital

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM SKOT (Sets, Kits, Outfits, and Tools)

OBJECTIVE: A nondestructive diagnostic measurement system is needed to assess the integrity of the manufactured parts and validate their material properties.

DESCRIPTION: The goal of the project is to develop a smart, portable diagnostic measurement system that can take manufactured parts from the Mobile Parts Hospital (MPH) and verify their integrity. The system has to work with parts of complex geometry and assess both geometric as well as performance integrity. To accomplish this goal, the system should find defects in the part volume and characterize material properties. The system should be cost effective and provide digital data archiving. A longer term secondary objective is to provide a means to compare the new part with the one being replaced.

PHASE I: Identify the diagnostic measurements required to accomplish the objectives. Demonstrate that the approach will achieve the necessary measurements in material systems appropriate for these tests. Validation of the concept should include crack detection to 0.01 and characterization of material properties such as density and strength. Design a Non-Destructive Evaluation (NDE) system that will meet the challenges of a mobile platform to be used by soldiers in the field.
PHASE II: Build a prototype Non-Destructive Evaluation (NDE) system that can take manufactured parts, perform an inspection and validate the parts integrity as to both defects as well as material properties. Testing should include parts manufactured with laser fused powder metallurgy with controlled process variables to simulate possible manufacturing defects. System should utilize a smart data processor able to interpret the measurements and provide assessment to the operator.

PHASE III DUAL USE APPLICATIONS: Future combat systems will require rapid replacement of damaged parts. In the commercial sector, replacement of legacy parts will become a critical requirement for aging vehicles and equipment. The inability to find hard-to-replace parts may be the critical factor causing otherwise serviceable systems to be retired. The combination of the MPH with parts integrity assurance can be a significant contributor to extending the useful life of costly hardware.

Diagnostic materials characterization technologies are applicable to broad areas of manufacturing process assessment/control as well as materials lifetime degradation. Specific applications include heat treatment, of metals, fatigue life assessment, curing of composites, fiber/resin ratio assessment, fiber orientation, interlaminar properties, and others.

REFERENCES:

KEYWORDS: Materials, Sensors, Information Processing, Smart Portable Diagnostic Measurement System, NDE System, Inspection, Rapid Replacement, and Material properties

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems

OBJECTIVE: Develop a computational software model which can demonstrate and predict landmine detonation forces and loading conditions (pressure, blast velocity, total impulse, as well as expected dynamic and static vehicle deformations) over a variety of soil conditions.

DESCRIPTION: The Army is interested in the development of an advanced analytical and numerical software model which would better predict the explicit blast forces and loading conditions of a blast event from buried landmines (either anti-personnel, anti-tank or an improvised explosive devices) in a variety of soil conditions. This work would develop advanced analytical and numerical models that would couple blast load, material properties, and expected structural response of a vehicle design. Technical efforts would focus upon the continuous advancement of finite element (FE) computational models that can combine mine blast loading models with material models and structure finite element concepts. Such a model would be used to conduct blast protection analysis in a developing ground vehicle design prototype. Current models tend to have elements of these kinds of computations, but do not incorporate a full system of models from the blast interaction with soils to the crew compartment reaction.

PHASE I: Conceptualize and design the methods needed which will increase accuracy of the results of modeling and simulation of a mine blast event. Design should include a variety of blast types (landmines, IED, etc.) and soil conditions. Develop and demonstrate initial software for model. Determine potential upgrades and expanded features.

PHASE II: Validate existing software model based on Phase I work. Determine improvements and debug as needed. Determine potential upgrades.
PHASE III DUAL USE: The completed software could be expanded for use over a broad range of military and civilian security applications where the need for modeling of landmines, IEDs, or demolition explosives might be utilized. Within the Army these might include, but not limited to, ground vehicle design analysis, countermine equipment, EOD issues, and personal protection issues. Within civilian security applications, this software might be utilized in a variety of homeland defense technology development as well as police bomb squad technology development.

REFERENCES:

KEYWORDS: landmine, blast protection, computational model, detonation forces, finite element analysis

A04-238 TITLE: Visualization Tool for Animating Combined Multibody Dynamics and Computational Fluid Dynamics Simulations

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Petroleum and Water Systems

OBJECTIVE: To develop a visualization tool that uses the results of a combined computational fluid dynamics (CFD) and multibody dynamics simulation to animate the motions of a vehicle and its sloshing liquid payload.

DESCRIPTION: Research is currently being conducted to develop a methodology that combines commercially available software for the purpose of simulating the combined effects of a vehicle performing on-road and off-road maneuvers and the resulting sloshing motions of a liquid payload that the vehicle is carrying. The vehicle motions will be simulated using the multibody dynamics software ADAMS and the fluid sloshing will be modeled using either the Fluent or Flow3D CFD software. The methodology incorporates a “glue code” which manages the time steps of the two commercial-based software packages and passes the necessary system state information needed to simulate the vehicle/tank at each solver time step. Now a tool needs to be developed that will take the simulation results for each timestep and marry them up with three-dimensional graphical representations of the vehicle and the fluid tank. The resulting animation will show the vehicle interacting with its surrounding environment and the sloshing motion of the fluid in a semi-transparent tank. This visualization tool will help the user of the sloshing methodology better understand how fluid motions are contributing to vehicle instability when performing severe maneuvers. In addition, this tool will also be used to help tank designers explore a variety of tank geometries and baffling schemes and determine which configuration is best suited for the particular mission profile of the vehicle hauling the tank.

PHASE I: Identify coupled CFD/multibody dynamics simulation output parameters needed to animate a vehicle and its sloshing payload and how those parameters will interact with tank/vehicle Computer Aided Design (CAD) geometries. Determine the extent of functionality that the software will need and the ease of use to be a useful tool for both engineers and non-technical people. Develop screen-shot prototypes of the software demonstrating its functionality. Identify a variety of CAD software formats that will be compatible with the visualization tool and how the tool will be maintained to support future revisions of that CAD software.

PHASE II: Fully develop the sloshing visualization tool that was explored in Phase I. The end product of Phase II will be fully functional software that is useable in both Microsoft Windows and Unix environments. Demonstrate and validate the functionality of the tool using results from a current coupled simulation performed by the Army.
Develop a complete set of software documentation to help the user use the tool no matter what level of technical background they have.

PHASE III DUAL USE APPLICATIONS: This visualization tool could be used by a wide variety of commercial and Government entities. Its intended use is to observe large-volume fluid sloshing conditions in vehicles which can include any vehicle that hauls bulk fluid payloads in a highway setting or off-road (i.e. fuel haulers).

REFERENCES:

KEYWORDS: modeling, simulation, visualization, animation, sloshing, computational fluid dynamics, multibody dynamics

A04-239 TITLE: Multi-Resolution Modeling of Ground Platform Dynamic Performance and Mobility

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Tactical Vehicles

OBJECTIVE: Design method/algorithm and build software to create computer models of varying resolution that are consistent in their prediction of mobility performance. The method/algorithms would be used to create various resolution models from a source high-resolution model. Models created using this method would be applicable to the use of war game simulations for vehicle design purposes.

DESCRIPTION: This topic addresses modeling methods that produce models of varying resolution, while maintaining an overall consistent behavior in predicting vehicle mobility and dynamic performance. Models of three resolutions are targeted: (a) current engineering models (no consideration of real-time), (b) real-time, and (c) models of reduced complexity that allow many virtual entities to be operated simultaneously on low-cost computers (i.e., PCs) and facilitate operational effectiveness evaluations (war games). This topic includes concepts related to the process of identifying performance measures that should be consistent for all models, methods of creating lower resolution models from higher resolution models, separating a vehicle system model into several subsystems that may be modeled independently with varying levels of resolution, and aggregating components and subsystems into lower resolution systems.

PHASE I: Perform research into the topological construction of ground platform models, and decompose the system into a hierarchy that is flexible to changes in component modeling resolution. Analyze algorithms (topological, numerical, or other innovative methods) that show potential towards reduction in model resolution while minimizing the reduction in accuracy of model predictions. Analyze the methods and determine the best model reduction method. Identify “consistency metrics” that are used to measure the overall consistency of predictions from each resolution model. Phase I will also involve identifying the current state of the art in this area and identify subtopics that must be developed further if phase II were awarded.

PHASE II: Develop and implement the model reduction method identified in Phase I in software. Analytically map the reduction in accuracy and deviation from the consistency metrics to the model resolution. The end product of Phase II is the capability to start with a high-resolution vehicle dynamics model and: (1) reduce the model to a real-time capable model, and (2) reduce the model further to a reduced order model capable of running up to large numbers of entities on a single computer. The reductions should, to the greatest extent possible, be executed in a continuous manner, as opposed to large-change discrete resolutions (i.e., they should be of a variable resolution that could be tuned based upon how many entities are executed and/or computational resources available.

PHASE III DUAL USE APPLICATIONS: The software could be used by automotive, truck, and construction equipment developers in order to more accurately estimate case use history of the equipment they are developing.
REFERENCES:

KEYWORDS: modeling simulation multi-resolution wargame operational design concept

A04-240 TITLE: High-Power, High-Voltage, Bidirectional DC-DC Converter

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, Future Combat System

OBJECTIVE: Develop high power-density, high-temperature, efficient bi-directional dc-dc converter for hybrid vehicle power management

DESCRIPTION: Military hybrid-electric (HE) ground vehicles (Ref 1) would benefit significantly from a dc-dc converter to connect the vehicle battery pack to the high-voltage vehicle power supply (bus). Use of such a dc-dc converter has the potential to improve fuel economy, reliability and safety. At present, a high power (300kW), high voltage (750Vdc) dc-dc converter would be too large (>75 liters) to meet the volume constraints of the planned next-generation vehicles under development for the FCS (Future Combat Systems) Program. The limited efficiency of present dc-dc converters (approx. 85%) and the requirement for low-temperature coolant (70 degrees C) place additional burdens on the vehicle with respect to reduced fuel economy and larger radiator size. The main objective of this SBIR effort is to develop the technologies needed to: reduce the size of the converter, improve efficiency, and increase coolant temperature. The technologies must be demonstrated in a prototype dc-dc converter. The key performance parameter metrics are power density (kW/liter), efficiency (kW output/kW input), and coolant temperature. The most important parameter is power density. The contractor must design the converter in order to maximize power density while meeting the following efficiency and coolant temperature objectives. The coolant temperature objective is 100 degrees C inlet temperature measured while operating at full power under continuous operation. This temperature objective allows use of either water or oil coolant. The efficiency objective is 95%, measured at full power. These efficiency and coolant temperature objectives (95%, 100 degrees C) are themselves a significant improvement over the state of the art (85%, 70 degrees C). The power density objective is to increase from a present value of 4kW/liter to greater than 8kW/liter. The contractor must select and develop the technologies to meet these objectives, which may include semiconductor, thermal management, semiconductor packaging, control, and passive component technologies. The lower-voltage terminals of the converter must operate over a dc voltage range from 200V to 300 V. This voltage level is similar to that of battery packs used in hybrid electric demonstrator vehicles and represents the battery pack voltage at various states of charge. The higher-voltage terminals of the converter must operate at 750 Vdc. This 750V voltage level is similar to voltages used in hybrid electric demonstrators, and corresponds to a high voltage distribution bus. The converter must be capable of transferring power bidirectionally (from its low voltage terminals to its high voltage terminals, and from its high voltage terminals to its low voltage terminals). When providing power to the higher voltage terminals, the converter must be able to source a continuous current of 400 Adc at 750Vdc, corresponding to a 300kW output. This represents the battery pack supplying power to the vehicle. Providing power to the lower voltage terminals represents charging the battery pack from the vehicle high voltage bus.

PHASE I: Contractor shall develop a comprehensive converter design to achieve power density, efficiency and coolant temperature objectives. Contractor shall use electrical and thermal modeling, and component testing and
evaluation to provide proof-of-concept. Where novel components are employed, contractor shall validate component performance. Sub-scale converter prototypes are encouraged.

PHASE II: Contractor shall optimize the design, and build a full-scale converter. Contractor shall perform a thorough test and evaluation, and characterize the converter over the full range of input/output voltages and temperature. Power and power density must be measured. One prototype 300 kW converter must be delivered to TACOM.

PHASE III DUAL USE APPLICATIONS: Converters developed under this SBIR can be expected to find application in FCS HE vehicles, RST-V, and HE upgrades to current force (Stryker, HMMWV). The technology developed in this SBIR can be scaled to meet Air Force MEA and Navy applications, and may find application in other converters needed for FCS, such as motor drive inverters and pulsed power dc-dc converters. Commercial applications may include heavy hybrid electric trucks and construction vehicles.


KEYWORDS: hybrid electric, dc-dc converter, electrical power system, power density, high temperature electronics, RST-V, CHPS (Combat Hybrid Power Systems)

A04-241 TITLE: High Power Density, High Torque Density, Efficient Electric Motors and Generators

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM – Future Combat Systems (FCS)

OBJECTIVE: The Army is interested in the development and demonstration of advanced high power density, high torque density traction motors and generators for hybrid electric vehicles. Innovative research in the areas of materials and/or design reconfiguration of the traction motor and generator, is needed with the objectives of making these components smaller, lighter, more efficient, and rugged enough to meet the mobility and weight/volume requirements of the Future Combat System (FCS) vehicles.

DESCRIPTION: Current motors and generators used in Hybrid Electric Drives present great challenges with their weight and volume, and they need to be optimized for military vehicles applications. In order to meet the the FCS’s mobility requirements within the small available spaces in the vehicle, innovative approaches are needed to produce higher torque density and higher power density motors/generators without exceeding their thermal limits(-40 to +65 degrees Celsius). This may be done with the use of new magnetic materials, coating materials, winding processes, and/or new design configuration (stator/rotor reconfiguration, radial gap, axial gap, pancake type motor or cup type motor, etc.). The new motor/generator’s design must be scalable in power and torque. Scalability to higher power and torque levels are essential and must be supported by modeling and simulation. Scalability will help the Army to use the same motors and generators technologies for in-hub, axle and sprocket drive applications.

Target parameters for generators are power density of 5 kW/liter and continuous power of 50kW. Target parameters for electric motors are power density of 5 kW/liter, continuous power of 50kW, and torque density of 20 N-m/liter. Motor design must be able to meet form-factor and g-force requirements for in-hub wheel applications, while maintaining low unsprung weight. The new advanced motors and generators must be efficient and capable to operate at maximum rated power in high ambient (+65 degrees Celsius) temperature.
PHASE I: Research new design/material approaches and determine technical feasibilities for a new advanced high power density, high torque density traction motor/generator for hybrid electric vehicles. The goal of the new motor/generator design is to be scalable and meet the target performance parameters as stated above in the description section. The design scalability to higher power levels must be supported by modeling and simulation.

PHASE II: Using the results obtained from Phase I, the contractor shall develop, demonstrate and deliver a 50KW motor/generator prototype to TARDEC. This effort will include final design and a thorough electrical and thermal tests and evaluations.

PHASE III DUAL USE APPLICATIONS: Traction motors used in hybrid electric vehicles are the most common component technology that supports both the military and commercial sectors. The two most commonly used types of motors are the AC induction and the permanent magnet, none of which has been fully optimized to meet the torque/speed requirements of either the military or the commercial truck applications. The AC induction motor is too large and too heavy to fit in the available space and the permanent magnet although smaller and more efficient lacks adequate field weakening capability at higher speeds. Current development addresses these issues and can result in an optimized motor for both commercial and military vehicles. This development also looks into in-hub motors for wheeled vehicles which are very desirable. However, in-hub motors must meet a certain weight requirements which are achievable with further development of new magnet materials.

REFERENCES:
1) “Electric drive for wheeled and tracked vehicles-Comparative Issues, Mongeau, P. and Henrickson, W., AECV Conference 2003, Angers, France
2) “Advanced Hybrid Electric Wheel Drive, 8x8 (AHED) Vehicle Program, General Dynamic Land system, Trszaska, T., AECV Conference 2002, Noordwijkerhout, Netherlands.

KEYWORDS: Motor, generator, power, torque, density, hybrid electric, mobility, scalability, magnetic, coating, winding, stator, rotor, radial, axial, gap, pancake, cup.

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Medium Tactical Vehicles

OBJECTIVE: In the area of filtration the Army is continuing to explore new technologies that will provide less maintenance through increased service life and provide sensor technology that will determine the actual remaining service life of a filtration component (ex. Filter element). Also, sensor technology can be used to determine when a component is not meeting performance requirements and its useful life is nearing completion or the component is not functioning properly.

The major areas of filtration includes: oil, fuel, engine air, transmission and hydraulic. These filters are generally replaced on a mileage or time basis regardless of condition. Premature replacement of these filters adds to the logistic burden resulting in high spare parts replacement costs. A goal is to provide longer life filters by a factor of 2 while still maintaining efficiency and other performance requirements. An equally important goal is to provide sensor technology to filtration systems and their components to determine remaining service life or when a filtration system is inoperative or approaching an impending failure.

DESCRIPTION: New technology sensor development will be explored for filtration systems. Examples of sensor development include the following: (1) determination of impending fuel pump failure (percent of service life left) especially when inaccessible such as installation inside fuel tank, (2) sensor development to determine when the full flow oil filter is in the by-pass mode, (3) pre-cleaner scavenging sensor to determine any blockage in scavenging exhaust tube, and (4) engine fuel filter sensor to determine percentage of service life left. These types of sensor development efforts or related sensor development ideas which are known to be needed by military or commercial vehicle developers and their customers will be explored for feasibility potential.
Development of new innovative filtration designs will also be explored on an equal priority basis with new sensor technology. Both technologies can be combined together or explored independently as a stand alone program. Longer life filters and sensor development will lead to reduced spare part purchases and cost savings in a military and/or commercial vehicle’s operational cost. These development efforts will be a cost driver for minimizing maintenance costs and in helping diagnose what filtration components need replacing. The HMMWV is an example of a high density vehicle fleet that requires continual filter replacement on a time or mileage basis. These spare parts add to vehicle operational costs and increased maintenance and labor burden. All filtration new technologies will strive to achieve an increase in service life by a factor of 2 while maintaining the required performance and durability specifications.

PHASE I: The contractor will design concepts for a new filtration system in following areas: engine oil/fuel/air and filters for hydraulic and/or transmission. The contractor may also develop and design new sensor technology devices which interface with existing or future military and commercial filtration systems and components. A new filtration system and sensor technology concept is considered equally important. The contractor may choose either technology as a separate program or combine both technologies. It is desired that the contractor survey the selected technology(s) which currently exist in either commercial or military sector to become familiar and establish strong background support. This support base can lead to establishing current shortcoming existing in filtration systems albeit in the commercial and/or military sector. Also, this data base can substantiate and verify the technical feasibility approach concept. Strong support for the new filtration system technology and/or new sensor technology device will provide a jump start to enhance and provide a plan for practical deployment of the proposed concept. The technical feasibility will be integrated thru various design approaches and modeling/simulating techniques. Computational fluid dynamic studies will be used to interface with the various design approaches. The contractor will perform an analysis of the proposed concept to show predicted performance versus current performance requirements. If contractor’s proposed concept has previous sufficient exploratory design background a conceptual design and bread board reduced size prototype may be developed and initial lab test experiments conducted. An initial cost savings projection of the new technology concept will be provided based on a target 2X increase in service life.

PHASE II: The new technology filtration system and/or sensor technology concept will be fabricated and constructed based on Phase I modeling, design and computational fluid dynamic analysis. A brass board Phase II prototype hardware system will be built based on Phase I work. The technology concept will be assembled and extensive experiments conducted. Test results will be analyzed and results compared to the targeted 2X increase in service life goal. Design up-grades will be performed and experiments repeated where performance and service life goals fall short based on performance goals predicted in Phase I. During these experiments the design of the brass board prototype will undergo material tradeoff analysis to determine the best material selection for design and manufacturing processes. The new filtration concept will be verified that it can meet all requirements of the filtration unit it may be replacing or can meet requirements for a new vehicle system. This may require comparison tests between production units and new filtration concept including testing to parameters and conditions when installed on engines and vehicles. A new sensor technology development will be required to meet life cycle requirements for durability and reliability as well as all vehicle environmental requirements.

The technology concept will undergo test experiments and design up-dates until its design is hardened to reached desired performance and reliability/durability goals. Continuing improved manufacturing techniques and innovations will be assessed to bring manufacturing costs at a minimum design to cost ratio. In addition, a more detailed cost and economic analysis will be conducted to assure the technology concept will be cost effective per military and commercial sector guidelines. At the conclusion of Phase II the contractor will deliver at least one (1) prototype.

PHASE III DUAL USE APPLICATIONS: Success of the program will lead to direct utilization of this technology concept to the military and commercial market. Commercial markets deploy technologies that are cost effective and meet required performance requirements. Likewise the military deploys technologies that are cost effective and have been accepted commercially providing more stringent performance requirements can be meet. There is wide spread commonality between the Army’s tactical wheeled vehicles and commercial wheeled vehicles. These include the commercial H1 Hummer and the military HMMWV and the M915/M916 Series Truck which is a commercial truck modified for line-haul applications.
REFERENCES:
1) HMMWV Lubrication Order, Army LO 9-2320-280-12, Dated 19 June 1990, Replace oil filter every 3,000 miles or semiannually, whichever occurs first. This coincides with the engine oil change interval.
2) Subject: Condition Based Maintenance Plus Policy, Includes designing systems that require minimum maintenance, Department of Defense Policy (DoD), Dated 27 Jan 03


A04-243 TITLE: Design of New Technology Final Drives for 21st Century Military Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat System (FCS)

OBJECTIVE: The objective of this effort is to design and develop new technology final drives for Future Combat Systems (FCS) which will achieve one or all of the following: (1) reduced weight; (2) improved efficiency; (3) new sensor techniques to alert impending failure such as low lubricant level and; (4) longer durability and service life by a factor of 2. These goals are vital to obtaining new 21st Century final drives which will make a contribution to the Army's and vehicle developers demands for lighter weight and improved mobility to increase vehicle performance and capability. Final drive technology must strive to make improvements for achieving Army and vehicle developer improved goals.

DESCRIPTION: New design and technology advances in final drive research will be explored. Promising concepts will under-go a trade-off analysis and the best ideas will be prototyped, built and evaluated. The evaluating process will attempt to make a major impact in reducing final drive weight and/or improving final drive efficiency. Final drive weight reduction will include new lighter weight materials or other ideas such as a smaller quantity of oil usage and reduced parts counts through new engineering techniques and designs. Any new design will be thoroughly evaluated and compared to current production final drive. The new developed final drive will be required to meet all requirements of current production final drive.

Final drive technology will also explore new oil formulations such as synthetic oils providing the oil is common with the engine and/or transmission. A longer life synthetic lubricant would result in reduced maintenance and Operation Savings and Cost Reduction (OSCR) following a detailed economic analysis study. Also, other new oil formulations which provide compatibility between engine, transmission and final drive will be evaluated where a significant increase in the oil change interval shows promise. This will provide a means to reduce the maintenance burden and quantities of oil required in the oil supply pipe line for storage and distribution.

Other areas of final drive technology which will be explored includes a longer life and more durable final drive by a factor of 2 over current final drive technology. This could include exploring new seal technology to lesson oil leakage when final drive becomes damaged. In companion with a longer life final drive, sensor technology will be evaluated. This will provide a means to evaluate a reliable sensor design which alerts the vehicle operator when an impending failure in final drive is near term. This would also provide OSCR benefits.

PHASE I: The contractor, if not already, will become familiar with current combat vehicle final drives. This will provide a basis for developing new design approaches and determining technical feasibility for a new concept final drive for new vehicle systems such as Future Combat System (FCS). Modeling and simulation techniques will be applied which can provide one or more of the following new technical thrust areas: (1) Reduced weight thru light weight materials for final drive component; (2) improved efficiency to increase vehicle performance and power output; (3) new sensor techniques to alert impending failure caused by low oil level or bearing/seal damage; (4) final drive oil compatibility between all major propulsion components (engine and transmission) and; (5) longer durability and reliability to provide a 2X increase in service life. The contractor's new technology final drive will incorporate and establish preliminary design and an analysis of projected performance goals. In addition, the
contractor will develop an initial concept design and model key final drive components. During the design process the contractor will investigate and conduct limited testing of new or advanced materials which make up the final drive. In addition, preliminary process designs used in manufacturing will be explored to reduce design to cost. A preliminary projected cost savings will be provided which substantiates potential cost savings. Based on contractor’s current knowledge and expertise a reduced scale bread board functioning or non functioning prototype may be constructed to demonstrate the concept.

PHASE II: The contractor’s new final drive concept will be tooled for component build based on Phase I modeling and simulation analysis. A prototype brass board working system will be fabricated and assembled. Experimental tests will be conducted to verify the performance parameter expected or projected in Phase I. A detailed plan for the experimental tests will be formulated to show the practical implementation progress leading to a hardened final drive concept for achieving established performance goals. Experimental tests will continue with final drive design up-dates being made until performance and durability/reliability goals are more thoroughly verified and confirmed. The experimental tests will be based on current final drive test method/procedures and performance requirements. During design up-date and testing period the final drive concept will be assessed for more detailed design to cost and manufacturing practices and process to establish a highly competitive new design approach. The improved technologies obtained from this project will be thoroughly analyzed and form the basis for an advanced final drive applicable to new vehicle programs such as FCS. The concluding final drive concept will undergo a more detailed trade-off analysis which will formulate an up-graded economic and cost analysis to substantiate cost effectiveness for military acceptance. At conclusion of Phase II the contractor will deliver at least one (1) prototype final drive.

PHASE III Dual use Applications: Next Generation final drives will be applicable to military and commercial off-road equipment such as bulldozers. If performance goals in specific areas of efficiency can be achieved, vehicle operational costs are reduced and user acceptance is high. Likewise final drive technology that provides increased durability/reliability will be quickly targeted for future military and commercial use.

REFERENCES:
1) SUBJECT: Condition Based Maintenance Plus Policy, stresses: designing systems that require minimum maintenance, and new design technologies for smaller maintenance and logistic support footprints, Department of Defense Policy (DoD), dated 27 Jan 03.

KEYWORDS: Final Drive, Final Drive Efficiency, Final Drive Technology, Final Drive Components, Final Drive Materials

A04-244 TITLE: Advanced Suspension Characterization Test Fixture

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Petroleum and Water Systems (PAWS)

OBJECTIVE: To research, develop, and demonstrate an advanced suspension characterization simulation system for a wide variety of existing and experimental suspension systems that provides reliable suspension characteristic input for high-resolution, multi-body, ground-based vehicle models, thus providing significant cost and time savings in research, development, engineering and testing in both legacy and Future Combat System programs.

DESCRIPTION: Virtual models of existing and experimental ground vehicles are being developed in order to accurately evaluate a vehicle’s performance over a wide range of mission scenarios. The result of this type of research is significant cost and time savings in creating, modifying, and ultimately proving legacy and cutting-edge designs. By researching and developing unique state-of-the-art physical simulation equipment, the Modeling and Simulation Group at the Tank-Automotive Research Development Engineering Center has in-house solutions to extract key characterization parameter inputs from various systems and subsystems for the virtual ground vehicle models.
The aim of this SBIR research effort is to develop an advanced ground vehicle suspension characterization simulation system that will allow a complete assessment of an entire suspension system in both legacy and future ground vehicles. The envisioned system would be able to accommodate all types of suspension systems (passive, active, magnetic, controlled, experimental, etc.) up to four axles. An integrated data acquisition system would need to be implemented to collect key suspension characteristics and store them in an easily accessible file format. The suspension characteristics needed for accurate models include, but are not limited to, but at a minimum should be:

- Suspension Force vs. Deflection
- Spring Force/Deflection (jounce/rebound)
- Shock Force/Velocity Deflection (jounce/rebound)
- Tire force vs. Deflection
- Jounce Damping Characteristics
- Rebound Damping Characteristics
- Roll Center
- Roll Steer
- Suspension Roll Moment vs. Roll Angle
- Suspension Roll Damping vs. Roll Velocity
- Suspension Jounce Direction Spring Force vs. Deflection Curve measured at the wheel
- Frame twist deflection/rigidity evaluation

PHASE I: Identify feasible design concepts and methods for determining and storing key suspension system characteristics in legacy, FCS, and non-existent military ground vehicles. Demonstrate the accuracies and trade-offs of various design parameters.

PHASE II: Develop and demonstrate a working prototype using a well-defined legacy ground vehicle suspension system. In addition, demonstrate the capability to characterize vehicles up to 4 axles with various types of suspension systems as well as the ability to adapt to non-existent suspension systems.

PHASE III DUAL USE APPLICATIONS: A direct military application would be to provide quick feedback on the strengths and weaknesses of a particular suspension system in any military vehicle. Using this feedback, innovations could be spurred in the commercial arena. The competition between various companies could lead the development of better suspension systems at a reduced cost to the military, both in procurement and maintainability.

REFERENCES:
4) Standards: SAE J1574-1 Measurement of Vehicle and Suspension Parameters for Directional Control Studies
5) SAE J1574-2 Measurement of Vehicle and Suspension Parameters for Directional Control Studies – Rationale

KEYWORDS: Suspension, Characteristics, Analytical, Model, Simulation, Jounce, Rebound, Roll

A04-245 TITLE: Advanced Military Fuel Cell Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Design and build an on-board JP-8/diesel desulphurization system that can be integrated with a reformer for generating clean hydrogen to power a proton exchange membrane (PEM) fuel cell.

DESCRIPTION: While PEM fuel cells offer the ability to efficiently generate electricity with virtually no emissions and very low signature, fueling them is an enormous difficulty, especially for the army. Hydrogen will probably never become a logistic fuel due to its inherent physical limitations. The most likely source of hydrogen will be from reformation of JP-8, our current battlefield fuel. While reformation is possible now, there is one major hurdle left before a PEM fuel cell can operate off the reformate. JP-8 is a high sulphur fuel, and sulphur is a poison
to PEM fuel cells. For reformation of JP-8 to ever be feasible in the field, a lightweight, small scale desulphurization process must be developed to work in concert with an on-board reformer and fuel cell system. This process must be durable, reliable, and able to operate in a harsh battlefield environment.

The army is looking for a system sized for a 5 - 10 kW PEM fuel cell that will act as an auxiliary power unit on military ground vehicles. The reformer must be able to run for a duty cycle averaging between 3 to 8 hours, and be regenerable after use. The system must be able to run on JP-8 with a military specification of up to 3000 parts per million (ppm) sulfur, but typical sulfur levels will be in the 500 to 600 ppm range.

PHASE I: Develop an overall brassboard system that can take either liquid or vaporized diesel fuel and remove the sulphur, including how the unit will be integrated in-line with an on-board reformer.

PHASE II: Integrate the system into a package the can be demonstrated on a military ground vehicle. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL USE APPLICATIONS: This system could be used in a wide range of both military and civilian applications where traditional heavy carbon fuels infrastructure can be used to create hydrogen for PEM fuel cells-for example, auxiliary power units for RVs/Overnight truckers sleeper cabs, and stationary power generation applications.

REFERENCES:


KEYWORDS: desulphurization; PEM fuel cell; hydrogen; reformer;

A04-246 TITLE: Development of a Characterization Test System for Poweetrains of Military Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: To research, develop, and demonstrate a hybrid-electric/hybrid-hydraulic powertrain characterization simulation system that would allow characterization of a wide range of multi-wheeled and tactical vehicle advanced powertrains, thus resulting in significant time and cost savings in research, development, and engineering of both legacy Army systems, as well as Future Combat Systems programs.

DESCRIPTION: The hybrid-electric/hybrid-hydraulic powertrain characterization simulation system would allow experiments on a wide range of military vehicles and provide significant time and cost savings in development programs. The Army is acquiring new vehicles, tracked and multi-wheeled, that make use of non-conventional powertrain assemblies. Technologies such as hybrid propulsion, electric motors, fuel cells, as well as other advanced components are finding their way into military vehicles. The aim of this SBIR research effort is to develop a characterization simulation system which permits the evaluation of the complete powertrain from the back of the engine source to the wheels. This characterization simulation system would have to accommodate these new technologies as well as include the transmission, drive shafts, differentials, and related components. The envisioned system would have the capability to handle up to four axle systems to cover the wide range of U.S. Army vehicles. A complete simulation system programming and data acquisition system would also need to be implemented to provide needed capabilities for collecting data during durability and performance testing. The data can be used for conducting feasibility studies, provide inputs for modeling and simulation, or any other government application. All data must be accessible over the system network. All authorized personnel must be able to view the data as it becomes available.

PHASE I: Identify design concepts and methods that would prove successful in the characterizing, both analytically and physically, and data acquisition of the powertrain configurations (and subsequent advanced technologies) that are implemented into both legacy systems, and FCS vehicles.
PHASE II: Develop and demonstrate a working prototype test rig on an legacy system powertrain configuration and implement its use in TARDEC facilities. Demonstrate the capability to characterize components such as hybrid-electric drives, motors, and etc.; components not yet implemented into legacy vehicles, but are on the forefront of being an integral part of FCS.

PHASE III DUAL USE APPLICATIONS: This characterization simulation system could be used by a wide range of commercial and government agencies that focus on the need for collecting powertrain data from large scale vehicle systems. Furthermore, this technology has yet to be developed commercially, therefore through this SBIR effort, the Army is once again on the forefront of bringing technology to the commercial sector.

REFERENCES:

KEYWORDS: Powertrain, characterization, engine, transmission, data collection, testing

A04-247 TITLE: Complex Electronics Packaging Thermal/Signature Management Design Tool

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PM FCS

OBJECTIVE: Develop capability to analyze the specific problem of managing heat generated by multiple electronics packages in close proximity.

DESCRIPTION: A recent ‘pit stop’ engineering exercise for the Future Tactical Truck System demonstrated the very real problem that exists for designers of advanced light concepts. The number of electronic components on these smaller advanced systems threatens to become a power, weight, and heat burden. In order to optimize reliability and survivability, design engineers need a tool that can be used during rapid prototyping exercises to judge the consequences of grouping large complex electronics packages and/or rack mounted systems in close quarters. The Army and general industry need a program that looks at the specific thermal management (and the associated signature management) of multiple electronic systems, both individually and as a complete system, which is currently not available in a Commercial off the Shelf (COTS) program.

The Department of Defense (DoD), its vehicle developers, and much of the auto industry have invested heavily in the development of MuSES (and the commercial version RadTherm) for use in overall system thermal rapid prototyping and signature management. This firmly established, commercial dual-use code now has the ability for third parties to write user routines for increased capability. Since MuSES does not have this specific capability for predicting complex electronics packaging, the Army and industry could benefit from an innovative software module that does. This module should be easy to use, be flexible in its breadth of applicability, accurately predict the conduction, radiation, and convection modes of heat transfer of complex electronics packaging and pass this information into MuSES to allow for overall system prediction.

PHASE I: Goals for phase I should include a feasibility demonstration (e.g. concept analysis) of the proposed thermal/signature management design tool concept that is compatible with MuSES.

PHASE II: Goals for phase II should include a demonstration of a working prototype of the thermal/signature management design tool. The demonstration should display the tool’s capability to predict thermal loading of complex electronics packages with the results being compatible with MuSES. The Army should be able to take receipt of the prototype thermal/signature management design tool and use it for analysis.
PHASE III DUAL USE APPLICATIONS: Next generation vehicles are a major research and development activity within the automotive industry. The development, demonstration, and integration of robust thermal management technologies into electric and hybrid-electric vehicles represent numerous technical challenges requiring innovative solutions that in turn can be directly applied in the military and private sectors.

References:

KEYWORDS: Thermal management, signature, electronics

A04-248 TITLE: Cooling Objectives and Operative Leverage (COOL) Techniques

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: Tactical Vehicles

OBJECTIVE: Develop innovative cooling system components and techniques for obtaining higher performance, lighter weight, more effective cooling systems for military vehicles.

DESCRIPTION: Most military vehicles have cooling systems components including: radiators, fans, fan clutches, heat exchangers/charge air coolers (oil to water, air to water, oil to air, and air to air), shrouds, thermostats, water pumps and hoses/clamps. Military vehicle cooling systems operate at high coolant/oil temperatures when vehicles are heavily loaded (up to .7 tractive effort/weight ratio) and at high ambient temperatures conditions up to 120 degrees F. To meet the cooling requirements imposed by Army and vehicle developers, new techniques need to be developed to assure cooling system components do not exceed their intended design operating temperature limits specified by manufacturer. Future military vehicles will be lighter weight and incorporate electric drive technology with series or parallel hybrid designs. These changes will demand the development of improved performance significant state-of-the-art innovative cooling techniques and cooling component technology. New cooling component design and inventive cooling techniques will assure the optimized sized cooling system can provide desired performance while maintaining the required RAM-D goals.

Innovative cooling components and cooling system techniques will be designed, developed and evaluated through lab tests to verify that improved performance is obtainable. Improved performance of a new technology cooling system component can translate into reduced weight and or smaller space/volume utilization. Other ways to reduce weight is to develop cooling components that utilize composite or plastic type materials. Weight savings of up to 25 percent for cooling components such as radiators or charge air coolers will be developed and verified by test, demonstrating they can meet performance requirements. Cooling system component development will also strive to obtain a reduction in a vehicle’s maximum cooling temperatures currently specified for engine coolant, engine oil and transmission oil. Reduction in these temperatures will result in improved vehicle reliability and reduced vehicle maintenance which is another driving force in this development effort. Also, goals of a reduction in a vehicle’s power requirements through electric water pump that require power only as demanded and idea’s for more efficient fan clutches will be sought as possible development effort.

In the past, cooling system degradation (such as coolant system leaks) accounted for up to 50 percent of engine failures according to one leading engine manufacturer. Therefore, to help diagnose a cooling system impending failure cooling system techniques such as: (1) dual level temperature sensor that in addition to recording temperature rise will track temperature rise with cooling system pressure and provide an early warning that pressure build up is not occurring signifying a leak, (2) a technique to determine exactly where the leak is occurring and
magnitude of leak, and (3) a means to determine when the cooling system is contaminated with debris/dirty fluid or has lost it’s coolant system additive package. These desired cooling system techniques or others similar ideas endorsed by military and/or commercial vehicle manufactures or user fleet owners will be investigated for potential application.

One other cooling system technique that may be considered will include a modeling of fan, fan clutch, shroud and radiator assembly to provide the ideal configuration and spacing to maximize cooling capability and provide the most effective cooling design package. Airflow versus restriction of additional cooling components such as intake and exhaust grilles (where applicable) and heat rejection performance of radiator are necessary inputs to verify the modeling program.

PHASE I: In Phase I, the Contractor will baseline a current cooling system for a selected military vehicle. The new proposed cooling system component or technique will be designed and developed to provide higher performance and/or lighter weight than baseline technology. The contractor must consider military environments and performance specifications. The proposed cooling concept must be able to fit within the tight volume constraints of existing cooling components. The contractor will establish a preliminary design of the new cooling system component or technique. A model will be developed and optimized for performance, size, and weight. Preliminary performance analysis of the model and initial lab evaluation will be use to demonstrate improved performance characteristics, compatibility and commonality with current vehicle cooling systems. Design goal will be to provide a new cooling system component or technique that is adaptable, flexible and provides commonality with current vehicle cooling systems. A successful Phase I SBIR contract will present substantial evidence which verifies that their newly developed cooling component or technique will obtain the objectives of higher performance, lighter weight and/or more effective cooling systems.

PHASE II: In Phase II the new cooling system component or technique will be built and tested to validate its improved performance in a laboratory environment. The contractor will continue to harden the selected design concept by making design improvements in the areas of performance, size and weight. The prototype will be upgraded and lab testing will be continued until the prototype can demonstrate the reliability and durability equal to or better than the production component it is replacing. The effectiveness and technical capabilities of the Phase II prototype will be verified through lab tests and assessed by technical experts in the field. The cost of the component or technique will be defined and any potential improvement technologies will be identified. A producibility study will be performed. At the conclusion of Phase II, the contractor will deliver at least one prototype cooling component or technique.

PHASE III DUAL USE APPLICATION: The development of a cooling system component or technique that demonstrates the ability to increase the effectiveness, performance and reduce the weight of an engine cooling system will be directly applicable to both the military and commercial sector.

REFERENCES:
1) SWRI Test, Non-aqueous Propylene Glycol Coolant in 6.2L Engine.

KEYWORDS: Engine Cooling Systems, Radiators, fans, fan clutches, heat exchangers/charge air coolers(oil to water, air to water, oil to air, and air to air), shrouds, thermostats, water pumps, hoses/clamps

A04-249 TITLE: Advanced Military Hybrid Technology

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, Future Combat System
OBJECTIVE: Research, investigate, develop and evaluate a hybrid energy storage control system consisting of a combination of two sources of energy such as batteries and ultra-capacitors.

DESCRIPTION: Hybrid electric ground vehicles require an advanced, compact, high energy-density electrical storage system to provide the high power and high energy needed for mobility, lethality, and survivability systems. A multiple energy storage system, such as batteries and ultra-capacitors, may provide the best overall performance. The control system required for of power management and distribution from multiple energy storage systems has not been done before. Battery-only energy storage systems have good energy storage capability, but are limited with respect to power density, cost, cycle life, and slow discharge. Ultra-capacitors have demonstrated good power density and cycle life, but cannot store the energy needed for long term operation. Capacitors are known to store energy in milli-seconds. This suggests that a hybrid energy storage system may provide superior power, energy and cycle life performance. The control mechanism for hybrid energy storage systems is a challenge. These systems (batteries and capacitors) have different physical, electrical, and chemical characteristics with different control (charge/discharge) methods. The challenge lies in combining both systems to control the energy. Concept of two systems meets the demand of storing and releasing the energy as needed for military. Ultra-caps and advanced batteries have been successfully demonstrated separately on hybrid vehicles but combining the two and simultaneously controlling their power and energy has never been demonstrated.

The objective of this SBIR is to design, develop, prototype and evaluate the control scheme of combining a hybrid energy storage system for hybrid electric application composed of both batteries and ultra-capacitors (ultra-cap/battery), and compare it with battery-only and ultra-capacitor-only storage systems. A thorough investigation and comparison of all storage systems will be demonstrated including cost, electrical and thermal performance, energy density and power density. Some possible solutions may include novel power switching and distribution/power conversion and a control system using microprocessors or software. The effort must include modeling and simulation of all energy sources (batteries, ultra-capacitors, ultra-cap/battery), and design, optimization and prototyping of the control system required for the multiple storage system (ultra-cap/battery), and thermal management. The performance of the energy storage system needs to meet or exceed a set of current specifications of 110 W-hr/kg or 1 kW/kg, long cycle life and charge and recharge acceptance during deceleration and braking.

PHASE I: Conduct research to investigate and evaluate the feasibility design concepts to demonstrate the control system required for a hybrid energy storage system consisting of batteries and ultra-capacitors, and comparing with single source systems. Phase I will address modeling and simulation of multiple energy sources and single energy sources. Phase I will also, select the most appropriate system for military and commercial vehicles.

PHASE II: Using the results obtained from the Phase I initial design concept, Phase II will develop, test, and demonstrate multiple or single energy source system prototypes based on the selected most suitable energy source.

PHASE III DUAL USE APPLICATIONS: Phase III will address the integration of the energy storage system in a vehicle with a hybrid electric drive for military and commercial applications. Energy storage for hybrid systems has never been optimized for best applications in both the military and commercial trucks. For the military, energy storage will be used for range and fast energy release i.e. energy and power. The same principle applies for commercial use although the application may vary. The commercial truck fleet needs energy storage in terms of batteries to achieve maximum fuel economy and optimize the engine operation within its best operation mode on the fuel map. However, transient operations that requires a burst of power to overcome the vehicle inertia and road resistance as is the case with acceleration and hill climbing are better served with ultra-capacitors. Oshkosh hybrid systems use Ultra-caps and other military and commercial trucks use batteries. Both systems experience inadequate energy storage in their duty cycles. A combination of batteries and ultra-caps has the potential to remedy the shortfalls of either system.

REFERENCES:
A04-250  TITLE: Development of Endurable Thermal Barrier Coatings for Diesel Engine Specific Heat Reduction

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, Future Combat System

OBJECTIVE: The objective is to define, develop, and demonstrate thermal barrier coating technology for diesel engine combustion surfaces and/or monolithic exhaust port runners that will improve overall propulsion system power density with respect to volume and/or weight through reduction of specific heat rejection while meeting RAM-D (Reliability, Accessability, Maintainability, Durability) durability and reliability goals.

DESCRIPTION: Anticipated future high output vehicle diesel engine operating conditions include cylinder loading that will approach 125 BHP per liter of engine displacement with 4 cycle brake mean effective pressure exceeding 350 PSIA and brake specific heat rejection to coolant of 18 BTU per BHP-Min or lower. Thermal barrier coatings for only in-cylinder diesel combustion surfaces will be considered in this topic and include the piston crown, the fire deck, and the valve face(s). Additionally, monoliths for strictly exhaust port runner application will receive consideration. Any proposal should include necessary bench top experimental analysis to assess coating candidate(s) thermal behavior and also an engine demonstration that includes operation at various high load conditions and relevant thermal cycling evaluation. Typical environmental boundary conditions include in-cylinder 20:1 air-fuel ratio, exhaust temperatures between 1400 - 1500 F, and peak firing pressure up to 3500 PSIA.

Engine RAM-D goal of 1000-hour life expectancy shall be pursued in all proposing coating technologies. Also, presented coating technologies shall be consistent with Army initiatives to reduce operating and support costs. Two generic cost drivers: 1) causes of electrical/mechanical replacement costs; and 2) causes of fuel/fuel distribution costs are directly applicable to this topic.

PHASE I: Identify and determine potential coatings that will be durable under high output conditions defined in the description through analysis and review of current state-of-the-art high temperature coating technology.

PHASE II: Demonstrate and validate performance and durability of selected coating(s) in a relevant engine operating environment. Conduct engine level testing of coated components selected in Phase I.

PHASE III: Development of durable thermal coatings have direct application to high output diesel engines that tend to operate at higher temperature and pressure in comparison to current commercial heavy-duty engines. Military application includes future development of high output, combat, low heat rejection engines and commercial use is targeted toward heavy-duty engines that are heading toward higher temperatures and pressures that may require thermal barriers coatings for combustion surfaces.

REFERENCES:

KEYWORDS: high output diesel engines, ceramic coatings, low heat rejection

A04-251  TITLE: Modular Generic Voltage Converters
TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Heavy Tactical Vehicles

OBJECTIVE: To develop a family of robust, inexpensive, multi-voltage DC to DC converters that are reprogrammable/switchable.

DESCRIPTION: DC/DC converters are typically dual voltage devices, i.e. 12 volt to 24 volt or 12 volt to 42 volt devices. With the advent of 42 volt electrical system vehicles and the hybrid vehicular power units, some of the vehicle operating voltage requirements are approaching 600 volts, and possibly even higher, while portions of the electrical system remain in the 12 (14) volt, 24 (28) volt, or 36 (42) volt range. A need has arisen for the development of a family of multi-range DC to DC converters. In order to be usable in Army vehicles the converters need to be designed to achieve electromagnetic compatibility (per applicable sections of MIL-STD-461E) and 24 volt electrical system compatibility (per MIL-STD-1275B), and have an operational temperature range of -45° C to 90° C. The developed multi-voltage DC to DC converters should be applicable to as many different voltages as practical by electronic, manual, or programmable switching. The “family” could be a single unit (preferable), a scalable unit, a modular unit, or a family of units using same components to the maximum extent possible.

PHASE I: Determine the requirements for a family of converters to operate in the 14/28/42 volt ranges, and also to convert to/from high voltage such as those seen on hybrid vehicle power busses, including the range of 300 to 600 volts. Review potential technologies that may be efficiently applied for various power levels that may be required in these voltage ranges. Design and model switchable or programmable converters that are useable at different power levels in these voltage ranges. Optimize the designs based on the modeling results.

PHASE II: Build prototypes of each of the proposed converters and test them in a laboratory environment. Based on laboratory testing results, optimize the converters as needed to meet the performance requirements and retest them. Test and validate the improvements.

PHASE III: The items developed under this SBIR will be applicable to, and necessary for, most future military and commercial vehicles, especially those with 42V electrical systems, Hybrid Electrical Vehicles (HEV), and Electrical Vehicles (EV).

REFERENCES:

KEYWORDS: DC/DC converters, multi-voltage, reprogrammable, reconfigurable, generic, modular, inexpensive, dual use.

A04-252 TITLE: Hands-Free Tele-Operation Via Physiological Signal Recognition

TECHNOLOGY AREAS: Ground/Sea Vehicles
OBJECTIVE: The objective of this program is to develop a system for recognizing specific physiological signals and translating them into commands for the remote operation of an unmanned ground vehicle.

DESCRIPTION: Tele-operation is currently the most reliable method for operating an unmanned ground vehicle. However, there are a number of disadvantages to standard methods of tele-operation, including the requirement for the soldier to give up his weapon in exchange for a control device. This topic seeks alternative hands-free methods for controlling robotic vehicles. It is envisioned that the system would be used by a soldier on foot, who would be controlling a small UGV. It is therefore necessary that the system be rugged, lightweight, must not impede the vision or physical movement of the user, and operate effectively in noisy environments. Information must be transmitted wirelessly from the soldier to the UGV and, while signal processing could be performed on the UGV, communications bandwidth should be kept to a minimum. The system needs to operate reliably at distances up to 20 meters, with minimal latency. We will consider a variety of modalities including, but not limited to, electroencephalogram (EEG), electromyogram (EMG), gestures, sub-vocalization and speech. The system must be non-invasive and undetectable at tactical distances. It must provide high correct classification rates and low rejection rates. The prototype lexicon is expected to be relatively small, with as few as six distinct commands, but the system design must have expansion capability. While extensive individual training is acceptable for the prototype system, the system design must allow for simple, efficient and accurate learning. Approaches will be compared on the effectiveness of vehicle control, burden on the user, system capability, ruggedness and cost. The prototype system must use communications protocols compatible with Cluster 5 of the Joint Tactical Radio System (JTRS).

PHASE I: The first phase consists of determining system modality, researching sensor options, investigating signal processing techniques and feature extraction algorithms, and showing feasibility on sample data. Documentation of design tradeoffs and projected classification accuracy shall be required in the final report.

PHASE II: The second phase consists of a final design and full implementation of the system. At the end of the contract, the prototype system shall be integrated with a robotic vehicle and successful operation shall be demonstrated. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in this project and a user's guide and technical specifications for the prototype system.

PHASE III DUAL USE APPLICATIONS: This technology has the potential to revolutionize the way people interact with computer systems. The initial commercial application is assistance for physically disabled persons. Other applications include vehicle control, video games and other human-machine-interface applications.

REFERENCES:
2) http://bci.epfl.ch
3) http://www.lce.hut.fi/research/bci/
4) http://www.plosbiology.org/plosonline/?request=get-document&doi=10.1371/journal.pbio.0000042
5) http://www.his.atr.co.jp/~wakumoto/hip/wirelessE.html

KEYWORDS: teleoperation, robotics, gesture recognition, speech recognition, brain-computer interface, haptic, bioelectric
OBJECTIVE: To develop a precise and reproducible bench test capable of distinguishing liquid transportation fuels, typically used by the military, of varying lubricity levels. In addition, the methodology must be capable of detecting the improvement in lubricity contributed by small additions of lubricity improvers, particularly those additives qualified under MIL-PRF-25017.

DESCRIPTION: Currently, the most accurate method of measuring fuel lubricity of an unknown sample fluid is to use the Rotary Injection Pump Test Rig. The rig detects/determines fuel lubricity and, in particular, the lubricity improvements provided by additives. Although reliable, the rig is very expensive costing over $27,000 to run every test and time consuming lasting 500 to 1000 test hours. Due to the high cost and time length, some bench scale instruments have been built to define fuel lubricity. However, it has been found recently these tests (i.e. HFFR, SLBOCLE) are not sensitive to additives. This project will focus on the development of a bench test procedure that is inexpensive and quick test that will differentiate fuels of different lubricity. The test should also be sensitive to small concentration of additives, i.e., at the recommended concentrations indicated for products qualified under MIL-PRF-25017.

PHASE I: Research current and concept lubricity bench equipment and associated components/methodology. Assess their potential capability to measure fuel lubricity, and identify effective/sensitive components. Determine if modifications can be made to meet objective requirements. Results will lead to an approach and procedure to follow under Phase II.

PHASE II: Put procedure and equipment together and initiate some preliminary testing that will indicate potential of procedure to meet objectives. Prepare such bench test and evaluate fuels of different lubricity levels (with and without additives). Test should be able to differentiate between the fuel's base lubricity and when additives are added to the fuel. Conduct a mini-round-robin with other laboratories to verify accuracy of procedure.

PHASE III: The developed bench test will make it more affordable to accurately determine fuel lubricity. Lubricity evaluators will be used to qualify/approve lubricity improver additives for both military and commercial applications. Jet Fuels, Ultra Low Sulfur Diesels (ULSD), and other next generation fuels will require lubricity improver additives in order to prevent catastrophic wear of engine components. An additive sensitive lubricity evaluator is necessary in order to improve fuel lubricity to satisfactory levels without resorting to costly additive overdosing. Additionally, this technology will also be utilized in commercial and military applications to quantitatively measure lubricity improvements provided by biodiesel when blended with conventional fuels.

REFERENCES:

KEYWORDS: Fuel, Lubricity, Additives, Rotary Injection Pump, Bench test

A04-254 TITLE: Preservative/Break-in Lubricating Oil

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: TACOM WAR RESERVE TEAM
OBJECTIVE: To define, develop, and demonstrate a preservative oil additive(s) (solute) capable of protecting internal engine, transmission, and non-hypoid final drive components during long-term storage from rust and other types of corrosion and material degradation without adversely affecting base fluid (solvent) performance.

DESCRIPTION: The long-term storage of military equipment requires aggressive prevention of corrosion through packaging and other preservative techniques. The current effort would research, develop and demonstrate a preservative oil additive that may be added to fully-formulated oil qualified to MIL-PRF-2104H. Any proposal should include necessary bench top experimental analysis to assess the additive candidate(s) preservative behavior and also a storage demonstration that includes a relevant thermal and humidity cycling evaluation. Typical environmental boundary conditions include temperatures ranging from 0 ºF to 120 ºF, relative humidity of 30 to 100 %, and sea water contamination from 0 to 2000 ppm.

PHASE I: Research and analyze current state-of-the-art preservative oil additive technology that will prevent corrosion and material degradation under the environmental conditions defined in the description. Assess the feasibility of these technologies to meet the project objective and identify the most promising technologies.

PHASE II: Using the results obtained from the Phase I research and analysis, develop and demonstrate preservative oil additive(s) which best fulfills objective requirements of this project. Validate performance of selected preservative oil additive(s) in a relevant long-term storage environment. Conduct engine, transmission and final drive level testing of preserved components to assess adverse effects in base fluid performance.

PHASE III: Development of preservative oil additives have direct application to a variety of engine, transmission, and non-hypoid final drive applications, as well as other internally lubricated systems were extended storage of components or entire vehicles occur. Examples of such uses include the remanufacture of replacement engines/transmissions in support of overseas conflicts, equipment stored on pre-positioned ships, and factory fill prior to shipment or storage by various OEMs.

REFERENCES:

KEYWORDS: Preservative, break-in, internal combustion engine, lubricating oil, tactical service, power transmission fluid

TITLE: Assured Operational Mobility Across Gaps for the Future Combat Systems/Future Force)
FCS/FF

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Bridging

OBJECTIVE: To develop a robotic gap defeat technology (GDT) that, at the end of Phase II, can be transitioned to a prototype system which will assure operational mobility and combat effectiveness to the Future Combat System/Future Force (FCS/FF) (1) and that also can be commercialized through dual-use government and civilian applications.

DESCRIPTION: Mobility is the essence of war. Gaps, both naturally occurring and intentionally created by the enemy, impede the momentum of assault. Current gap crossing equipment, necessarily, requires soldiers to launch/retrieve the bridge in hostile environments, potentially placing them in harms way. Current equipment are also not transportable in a C-130 aircraft, which is one of the key performance parameters for the FCS/FF (1). In summary, current gap crossing equipment places soldiers’ lives at risk in assault situations and are bulky for C-130 transportation.
The Unit of Action (UA) of the FCS/FF will comprise of assault vehicles, which have to self-sustaining for a period of 72 hours after deployment. After 72 hours, the UA may seek the assistance of the Unit of Employment (also part of the FCS/FF) for logistics support. The UE will comprise of vehicles of Military Load Class (MLC) 65.

The FCS/FF is proposed to be comprised of manned and un-manned vehicles, such as the Future Tactical Truck System (FTTS) (2). Projected curb weight (CW) of the FTTS is expected to be about 16 Tons. The FTTS will be comprised of a flat-rack, a smart crane and a payload. While on the highway, the proposed payload for the FTTS is restricted to 11 Tons excluding the flat-rack, whose weight is expected to be 2 Tons. While on the C-130 aircraft, the proposed payload is restricted to 6 Tons including the flat-rack, whose weight is expected to be 2 Tons. Gaps, to be defeated, range from 13/24m (Threshold/Objective). It may be noted that current launch/retrieve technology requires a large counter weight to balance the overturning moments caused by the bridge. Such large counterweights will be not be available in vehicular systems comprising the FCS/FF.

The main challenge posed to the Small Business is to propose innovative technological gap defeat solutions for gaps ranging from 13/24 meters (Threshold/Objective) based on an unmanned FTTS chassis that:
* Is robotically launched and retrieved;
* Does not exceed the payload carrying capacity (while on the highway or while in a C-130 aircraft);
* Is capable of sustaining vehicles up to and including Military Load Class (MLC) 65;
* Is volumetrically packaged to enable accommodation in a C-130 aircraft;
* Is capable of being loaded/unloaded in/out of the C130 aircraft using a roll-on/roll-off concept; and
* Is capable of being lifted (only the laid bridge and not the FTTS) from one location and being emplaced at another location by a CH-47 helicopter.

In summary, the small business has to be highly innovative to successfully address the challenges listed above. The challenges above require synergistic novel approaches in the technology areas of kinematics, robotics, power systems, optimized structural design, volumetric packaging and related aerodynamic issues. To minimize the development costs for this multi-constrained problem, the small business is highly encouraged to use modeling and simulation (M & S) techniques.

PHASE I: During Phase I, including the option, it is desired:
* To evaluate the technology concept(s) of the Phase I proposal for successful transition to Phase II;
* To demonstrate either through scaled model(s) and/or through simulations using M & S the innovation(s) forming the key to the success of the technology;
* To conduct risk analyses to successfully commercialize the technology and
* To identify any new applications of the technology, including other Department of Defense materiel systems.

In summary, the Phase I shall endeavor to place the technology towards a sound Phase II. Use of modeling and simulation is highly encouraged.

PHASE II: Based on the Phase I investigations and accomplishments, the Phase II shall clearly define and focus on transitioning to a prototype system development stage which will provide assured operational mobility and combat effectiveness to the FCS/FF. Use of modeling and simulation is highly encouraged. At the minimum, a demonstration of the gap defeat system to be robotically launched and retrieved along with its ability to sustain a static MLC 65 load is desired. A static skeleton platform, similar to the FTTS solely for the purpose of the above demonstration, may be used. The commercialization roadmap envisaged during Phase I shall further be refined to place the technology on a sound footing.

PHASE III DUAL USE APPLICATIONS: Potential dual-use applications of this SBIR are both Government and non-Government. Envisaged Government applications:
* US Marine Corps – To extend the developed technology to mobility related requirements;
* Homeland Security – To robotically emplace the GDT across debris in tight streets of cities and thus gain access to any nearby building/facility;
* NASA – To eliminate the need for an astronaut to physically be in the loop while assembling different modules of space stations;
* NASA – To robotically construct bridges on the MARS planet, while being colonized.
Envisaged non-Government applications:
Currently a number of infrastructure bridges are being constructed using lightweight composite materials. Despite the use of advanced materials, no major innovations in the methods to construct the same are observed. The technology developed in this program is anticipated to have a major impact to the construction techniques of bridges.

REFERENCES:
1) Operational Requirements Document (ORD) for the FCS, 14 April 2003.
2) http://www.ausa.org/PDFdocs/LWpapers/FTTS0803.pdf

KEYWORDS: FCS/OF, Military bridges, Mobility, Robotics, Future Tactical Truck System, C-130 aircraft, CH-47 helicopter

A04-256 TITLE: Multi-Power Source for MEMS Packaging

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM Heavy Tactical Vehicle

OBJECTIVE: The objective of this SBIR Program is to develop a methodology to use multi-power sources for heater-on-circuit techniques in MEMS packaging. The tasks are to compare various heating methods and their combinations for various MEMS applications; to study the processing parameters, their interactions, and the processing windows; to characterize the post processing performance and develop reliability/failure analysis methodologies.

DESCRIPTION: The concepts of multi-power sources, alternative current heating, and the heater-on-circuit are new in MEMS packaging. While most MEMS packaging processes are performed under global heating, a local heating is required and sometimes becomes critical to widen the packaging operation temperature window and protect temperature-sensitive circuits. The research of this SBIR into a multi-power heating takes advantage and overcomes the limitations of each single power source, thus provides an opportunity to develop a general MEMS packaging technology and platform for a wide range of materials, bonding mechanisms and applications.

PHASE I: Develop overall system design that includes specification of multi-power source for MEMS packaging technology, specification, operation, and identify the conditions for heat localization, energy management, and the effect on bonding reliability

PHASE II: Develop and demonstrate a prototype system with multi-power source for MEMS packaging in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL USE APPLICATIONS: Produce MEMS packaging system with multi-power source, and related operation software. This system could be used in a broad range of military and civilian applications where MEMS packaging and multi-power sources are necessary.

REFERENCES:
1) Microsystem Design; by Stephen Senturia.
2) The MEMS Handbook; by M. Gad-El-Hak.
3) Modeling of MEMS and NEMS; by John A. Pelesko and David H. Bernstein.

KEYWORDS: multi-power source, MEMS packaging

A04-257 TITLE: Advanced Military Trailer Technology

TECHNOLOGY AREAS: Ground/Sea Vehicles
ACQUISITION PROGRAM: PM Trailers

OBJECTIVE: Develop and identify advanced technologies for an advanced trailer, and design, and build an innovative demonstrator trailer satisfying Future Force requirements, as well as current military needs.

DESCRIPTION: The Future Force/Unit of Action (UA) battlefield requires extreme improvements in the mobility of its support vehicles. Trailers have historically been an afterthought in the design of military vehicles which has resulted in shortfalls in mobility, sustainability, versatility, commonality, transportability and deployability. Future Army missions will demand a "leap-ahead" in performance from sustainment/supporting vehicle platforms such as the Future Tactical Truck Systems (FTTS) and its companion trailers. These requirements include mobility comparable to combat vehicles (Future Combat Systems (FCS)) and use of the trailer platform for non-traditional roles such as transporting and operation of Unmanned Aerial and Ground Vehicles (UAV/UGV), and any number of mission modules to support the combat force to include automated resupply and rearm and emergency medical support modules. Because the trailer will be also be used with the existing fleet the study will in addition need to address current mission requirements.

The challenge to the SBIR contractor is to develop or identify innovative technologies such as:
- lightweight/high strength materials
- advanced suspensions
- power generation and storage
- robotic technologies

and design, build and demonstrate a next generation demonstrator trailer capable of satisfying the Army's Future Force battlefield requirements. Payload classes to be examined will be 11 tons and 2 ½ tons.

The contractor will be highly encouraged to develop the design using advanced computer modeling and simulation so that draft and final products of Phase I can be analyzed with Government models of military vehicles as prime movers.

The small business will need to be innovative in the technologies developed and integrated and in the actual trailer design. Part of this unique opportunity for the contractor will be exposure to the requirements and capabilities of major Army programs as well as advanced M&S.

PHASE I: Phase I of this SBIR effort should:
- Identify advanced technologies and assess their performance and risks, using limited component testing as needed, and provide detailed rationale for the trade-off analysis of the assessment decisions made
- Design and analyze the performance of a trailer integrating the chosen technologies through the use of M&S
- This should result in a feasibility study of the concept trailer and applicable technologies
- Examine the application of the advanced technologies to the current fleet of military trailers

PHASE II: For Phase II the contractor and government will determine the optimal design approach to satisfy the UA mission requirements based on the Phase I M&S and trade-off analysis, and the contractor will build a prototype of that configuration. This phase will focus on transitioning to a prototype phase with demonstrations of the trailer capabilities to possibly include use of TARDEC’s physical simulation equipment.

PHASE III DUAL USE APPLICATIONS: Potential military applications include sustainment vehicle companion trailers (logistics distribution platforms – cargo, petroleum, oils and lubricants POL, water, containers, and equipment), or utility vehicle companion trailers (general purpose, cargo, etc.). The prototype will also be made available to the User (i.e., soldiers/units) for an informal evaluation in the field.

Potential commercial applications include enhanced mobility for specialty trailers such as construction equipment haulers, mining, and other off-road applications. Improved agility/versatility technologies such as anti-roll-over and load-sensing could have application in commercial cargo transport safety. Improvements in commonality, maintainability and sustainability could have application in the commercial transportation industry to help save trucking/transportation companies on maintenance costs.
REFERENCES:
2) TRADOC Pamphlet 525-3-90.
3) The US Army Objective Force Operational and Organizational Plan Maneuver Unit of Action.

Prepared by Unit of Action Maneuver Battle Lab, Ft. Knox, KY, June 2003

KEYWORDS: ground vehicles, advanced suspension, hybrid power generation and storage, robotic technologies, advanced trailer prototype

A04-258 TITLE: Enhanced Access Control within a Pervasive Computing (PvC) Environment

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM LIS (Logistics Information Systems)

OBJECTIVE: To develop and design a system that provides secure connectivity and access control mechanisms across the rapidly expanding set of emerging pervasive computing (PvC) devices. The system will be architected and designed to advance the state-of-the-art in information management assurance & distribution, and seamless communications, by enabling the creation and management of community-of-interest (COI) domains – on demand. These COIs will provide secure connectivity between people and distributed processes using the appropriate level of authentication and encryption. This solution will leverage commercially available PvC technology and existing EAL 4, FIPS 140-2 certified products as appropriate to ensure data security and integrity.

DESCRIPTION: A critical element for achieving network centric warfare is the ability to provide the right information, to the right person or process, at the right time and location. Current PvC technologies permit users to access, via conventional and ad hoc networks, a variety of distributed applications and Web services, and to interact and collaborate with other users and processes seamlessly. PvC technology does not, however, provide secure, controlled and isolated access between processes and people in a flexible manner. This R&D activity will lay the technical foundation that will enable the DoD to dynamically create secure virtual channels, on top of existing PvC solutions, at a heretofore unseen level of granularity. Specifically, the system will have the ability to enable, or dynamically restrict, the flow of information between distributed systems, within flexible and secure COIs, based on authorization levels, and other dynamic information such as position. This capability will ensure that only authorized users and processes have access to critical information and only at the level required at that moment (e.g., restricted access can be given to coalition partners and reconfigured in real-time depending on our changing needs, etc.).

PHASE I: Research and analyze advanced security software architectures capable of creating and managing secure and dynamically reconfigurable COIs in a manner that supports current Army programs, such as Future Combat Systems (FCS), and Warfighter Information Network-Tactical (Win-T) systems. Develop resultant design concepts, and select optimal software architecture to be applied in the Phase II development.

PHASE II: Based on Phase I investigation and accomplishments, clearly define and develop prototype system which will be expanded to provide ease-of-use, transparency, mobility, single-sign-on user authentication, policy-based access management, and the flexibility to manage COIs. The system constructed will be tested with pertinent PvC and Security hardware and software and will be optimized for use by both military and commercial users.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian systems where information (e.g., text, voice, multimedia data, etc.) needs to move between mobile pervasive devices (e.g., vehicles, PDAs, cell phones, etc.) and back-end systems – securely. These non-defense related applications can be within the Homeland Defense, Law Enforcement, or Corporate or National Security domains.

REFERENCES:
OBJECTIVE: The use of petroleum fuels represents almost half of the logistics burden of a deployed force. The Total Army Analysis calculates that more than half of this fuel is consumed at fixed sites rather than mobile units, with cookstoves and generators being among the top consumers. An ideal approach to reducing the need to transport petroleum fuels into the theatre of operation would be the development of a skid-mounted system that converts readily available waste and biomass into fuels that could be used for cooking food, boiling water and/or generating electricity.

DESCRIPTION: Currently, petroleum fuels are used exclusively by deployed forces to operate their vehicles and equipment. Except for captured fuels, the fuel demand must be logistically supplied. This logistics burden could be reduced if useable fuels were manufactured nearer to or at the point of use from local sources of waste or biomass. Fuels manufactured from waste and/or biomass would not only reduce the logistics burden, but would also reduce waste disposal burden and environmental impact. Examples of readily available waste would include food scraps, used cooking oil, paper, cardboard and plastic. Sources of locally available biomass might include wood and agricultural products or by-products.

PHASE I: A study that shows how these waste and biomass feedstocks can be converted into fuels that could be utilized for cooking food, boiling water and/or generating electricity. This study should address the available wastes and bio-related resources near to or generated by a division-level camp. The study should then determine that the quantity and types available are sufficient to produce enough fuel to significantly reduce the logistics fuel that must be supplied to operate cookstoves and generators. Phase I will culminate in a report and a small demonstration to show that the waste products are converted into a fuel that can be used for cooking food, boiling water and/or generating electricity.

PHASE II: Depending on the findings from Phase I, Phase II would entail either a detailed engineering design for construction of a skid-mounted system or the actual construction of a prototype. "Similar" technologies are being developed in the commercial sector, these looking primarily at plastic packaging as the feedstock, or very large-scale plants used to produce ethanol for gasoline additives. These smaller "skid mounted" units would have commercial applications in rural areas, at resorts, campgrounds, etc. Phase II should also include a cost/benefit analysis of using these biologically derived fuels rather than transporting petroleum.

PHASE III: This technology is currently being developed for the commercial sector. Any of the work done under this program would have broad commercialization potential for the technology developer.

REFERENCES:
KEYWORDS: fuel, biomass, waste, electricity, generator, cookstove, biorefinery