# U.S. ARMY
# SUBMISSION OF PROPOSALS

## *Topics*

The Army works 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. Army scientists and technologists have developed 243 technical topics and the Phase III dual-use applications for each which address Army mission requirements. Only proposals submitted against the specific topics following this introduction will be accepted.

The Army is undertaking a transformation 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 Objective Force (OF), the Army has initiated the Future Combat Systems (FCS) program. The SBIR program has been aligned with FCS and OF technology categories -- this will be an ongoing process as OF/FCS needs change and evolve. All of the following Army topics reflect OF and FCS technology needs. Over 70% of the topics also reflect the interests of the Army acquisition (Program Manager/Program Executive Officer) community.

## *Please Note!*

- ✓ Your entire proposal (consisting of Proposal Cover Sheets, the full Technical Proposal, Cost Proposal, and Company Commercialization Report) must be submitted electronically through the DoD SBIR/STTR Proposal Submission Website. **A hardcopy is NOT required. Hand or electronic signature on the proposal is also NOT required.** You may visit the Army SBIR Website (address: http://www.aro.army.mil/arowash/rt/ ) to get started. This page links to the DoD-wide SBIR proposal submission system (available directly at http://www.dodsbir.net/submission), which will lead you through the preparation and submission of your proposal. Refer to section 3.4n at the front of this solicitation for detailed instructions on the Company Commercialization Report. You must include a Company Commercialization Report as part of each proposal you submit to the Army; however, it does not count against the proposal page limit. If you have not updated your commercialization information in the past year, or need to review a copy of your 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 review of the proposal.

- ✓ Based on past year's experiences with the electronic submission, please submit your proposals as early as possible.

- ✓ Be reminded that section 3.4.b 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 web site (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.

- ✓ The ***Phase II Plus*** Program objectives are to (1) extend Phase II R&D efforts beyond the current Phase II contract to meet the product, process, or service requirements of a third party investor, preferably an acquisition program, and (2) accelerate the Phase II project into the Phase III commercialization stage. "Third party investor" means Army (or other DoD) acquisition programs as well as the private sector. The general concept is to provide qualified Phase II businesses with additional Phase II SBIR funding if they can obtain matching non-SBIR funds from acquisition programs, the private sector, or both. Under ***Phase II Plus***, additional funds may be provided by modifying the Phase II contract, and where appropriate, use will be made of the flexibility afforded by the SBA 1993 Policy which allows total Phase I + Phase II SBIR funding to exceed $850,000. Additional SBIR matching funds, subject to availability, will be provided on a one-to-one matching basis with third-party funds, but not to exceed $250,000. The additional SBIR funds must be used for advancing the R&D-related elements of the project; third-party investor funds can be used for R&D or other business-related efforts to accelerate the innovation to commercialization. More information is available on the Army SBIR web site: http://www.aro.army.mil/arowash/rt/.

### *Phase I Proposal Guidelines*

The Army has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that the Army may exercise to fund interim Phase I - II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I is $70,000 over a period of up to 6 months. The Phase I Option, which **must** be proposed as part of the Phase I proposal if desired, covers activities over a period of up to four months and at a cost not to exceed $50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities which would lead, in the event of a Phase II award, 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**. Only Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of $850,000, the total funding amount available for Phase II activities under a resulting Phase II contract is $730,000, unless ***Phase II Plus*** funds are provided.

Companies submitting a Phase I proposal under this Solicitation must complete the Cost Proposal within a total cost of up to $70,000 (plus up to $50,000 for the Phase I Option, if desired). Phase I and Phase I Option costs must be shown separately; however, they 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. In addition, all offerors will prepare a Company Commercialization Report, for each proposal submitted. The Company Commercialization Report *does not count* toward the 25-page Phase I proposal limitation.

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.

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.

### *Phase II Proposal Guidelines*

Phase II proposals are invited by the Army from Phase I projects that have demonstrated the potential for commercialization of useful products and services. The invitation will be issued in writing by the Army organization responsible for the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Fast Track participants may submit a proposal without being invited, but the application must be received NLT 120 days after the Phase I contract is signed or by the Phase II submission date indicated later, whichever date is earliest. The Fast Track technical proposal is due by the Phase II proposal submission date indicated later. 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 SBIR 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, and Fast Track proposals will be evaluated under the Fast Track standard discussed in section 4.3 at the front of this solicitation. Proposers are required to submit a budget for the entire 24 month Phase II period. During contract negotiation, the contracting officer may require a cost proposal for a base year and an option year, thus, proposers are advised to be mindful of this possibility. 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, 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.

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 top for information on the Phase I Option). 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 thus 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.

### *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 your proposal(s) well before the deadline. The Army does not accept late proposals.

**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. The Army will NOT accept proposals which are improperly submitted. 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.**

### *Electronic Submission of Proposals Using the DoD SBIR Proposal Submission System*

Your entire proposal must be submitted using the online submission system. This site allows your company to come in any time (prior to deadline) to upload an updated Technical Proposal or edit your Cover Sheets, Cost Proposal and Company Commercialization Report. **The Army WILL NOT accept any proposals which are not submitted through the on-line submission site (http://www.dodsbir.net/submission).** File uploads may take a great deal of time depending on your internet connection speed and file size. If you experience problems uploading your proposal, call the help desk (toll free) at 866-724-7457. You are responsible for performing a virus check on each proposal before uploading electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. The Army will not accept e-mail submissions.

***Reminder!*** Based on past year's experiences with the electronic submission, please submit your proposals early.

### *Key Dates*

| *Phase I* | | *Phase II* | |
|---|---|---|---|
| 03.2 Solicitation Open | 1 July - 14 August 2003 | Phase II Invitation | April 2004+ |
| Phase I Evaluations | August - November 2003 | Phase II Proposal Receipt | May 2004+ |
| Phase I Selections | November 2003 | Phase II Evaluations | June – July 2004 |
| Phase I Awards | December 2003* | Phase II Selections | July 2004 |
| | | Phase II Awards | November 2004* |

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

***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 (*detailed on the following page*).

***Inquiries***

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

MAJ Janice M. Baker
Army SBIR Program Manager
U.S. Army Research Office - Washington
Room 8N31
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
(703) 617-7425
FAX: (703) 617-8274

**ARMY SBIR PROGRAM**
**POINTS OF CONTACT (POC) SUMMARY**

| ***Research, Development & Engineering CTR*** | ***POC*** | ***Phone*** |
|---|---|---|
| ***U.S. Army Materiel Command*** | | |
| Armaments RD&E Center | Carol L'Hommedieu | (973) 724-4029 |
| Army Research Laboratory | Dean Hudson | (301) 394-4808 |
| Army Research | Dr. Ellen Segan | (919) 549-4240 |
| Aviation RD&E Center | Peggy Jackson | (757) 878-5400 |
| Communications Electronics Command | Suzanne Weeks | (732) 427-3275 |
| Edgewood Chemical Biological Center | Ron Hinkle | (410) 436-2031 |
| Missile RD&E Center | Otho Thomas | (256) 842-9227 |
| Natick Soldier Center | Dr. Gerald Raisanen | (508) 233-4223 |
| Simulation, Training Center | Mark Stoklosa | (407) 384-3928 |
| Tank Automotive RD&E Center | Alex Sandel | (586) 574-7545 |
| ***U.S. Army Test and Evaluation Command*** | | |
| Developmental Test Command | Nancy Weinbrenner | (410) 278-1477 |
| ***U.S. Army Corps of Engineers (Engineering Research Development Center)*** | | |
| Engineer Research & Development Center | Susan Nichols | (703) 428-6255 |
| ***Deputy Chief of Staff for Personnel (Army Research Institute)*** | | |
| Army Research Institute | Dr. Jonathan Kaplan | (703) 617-8828 |
| ***U.S. Army Space and Missile Defense Command*** | | |
| Space and Missile Defense Command | Jay Howland | (256) 955-1843 |
| ***Army Medical Command*** | | |
| Medical Research and Materiel Command | Jeannie Shinbur | (301) 619-7427 |

**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 their costs are shown separately. The Cost Proposal 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**. EST on August 14, 2003.

## ARMY 03.2 SBIR TITLE INDEX

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|---|---|
| A03-043 | Natural Hearing Restoration for Encapsulating Helmets |
| A03-044 | Polymers for Lightweight Small Arms Cartridge Cases |
| A03-045 | Configurable Tooling Systems for Complex Structures for Objective Force Survivability |
| A03-046 | Breathable, Chemical Resistant, Elastomeric Protective Clothing Material |
| A03-047 | Long Wave Infrared Acousto-Optic Materials |
| A03-048 | Ultra-Compact Doppler LIDAR (Light Detection and Ranging) for Unmanned Aerial/Ground Vehicles |
| A03-049 | Blast and Shock Damage Analysis |

**Army Research Office (ARO)**

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|---|---|
| A03-050 | Research and Development of Stochastic Optimal Control Algorithms for Mobile Communications Systems |
| A03-051 | Mixed-Feed Direct Methanol Fuel Cell |
| A03-052 | Self-Decontaminating Coatings |
| A03-053 | Detection of Drugs/Narcotics and Processing Components Using "Sniffing" Devices |
| A03-054 | Large Scale Biomaterial Production |
| A03-055 | Cross-Layer Wireless Networking for Low Energy Sensor Networks |
| A03-056 | Man Portable Personnel Detection Device for MOUT |
| A03-057 | High Power, High Efficiency Diode Sources for Pumping Eye-Safe Solid State Lasers |
| A03-058 | Chaotic Radio Frequency (RF) Sources for Ranging and Detection (RADAR) Applications |
| A03-059 | Compact Submillimeter-Wave Sources and Detectors for Biological and Chemical Spectroscopy |
| A03-060 | Personnel Detection and Warning Systems for Perimeter, Ambush, and Casualty Detection. |
| A03-061 | Integrated Computational Algorithms to Treat Fracture and Fragmentation |
| A03-062 | Integrated Information Interface for Electromagnetic Modeling and Simulation Tools |

**Army Test & Evaluation Center (ATEC)**

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|---|---|
| A03-063 | Remote Neurological Measurement and Sensing |
| A03-064 | Advanced Electro-Optical/InfraRed (EO/IR) Projector for Testing Imaging Sensors |
| A03-065 | Variable Cold-Stop for a Multi-Band Infrared Imagers |

**Aviation RD&E Center (AVRDEC)**

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|---|---|
| A03-066 | Airspace Management and Deconfliction of Networked UAV |
| A03-067 | Active Trim Tab Actuator For In-Flight Rotor Blade Tracking |
| A03-068 | Dismounted Small Unmanned Air Vehicle (SUAV) Associate |
| A03-069 | Advanced Technologies for Improved Part Power Performance in Small Turbine Engines |
| A03-070 | Merging Sensor and Stored Terrain Database Data for Rotorcraft Poor Visibility Weather Operations |
| A03-071 | Sensors for Detecting and Monitoring Fatigue Cracks |
| A03-072 | Self-Healing Composite Structures |
| A03-073 | Advanced Snubber/Damper for Bearingless Helicopter Main Rotor Blades |
| A03-074 | Health and Usage Monitoring System (HUMS) for Unmanned Aerial Vehicles (UAV) |
| A03-075 | Composite Fastener Development |
| A03-076 | Combat Rotorcraft Electromagnetic Interference (EMI) Suppression Technology |
| A03-077 | Analysis, Design & Test of Low Reynolds Number Rotors and Propellers |
| A03-078 | High Strength, Affordable Helicopter Gears |
| A03-079 | Miniature Inertial Reference System |

**Communications Electronics Command (CECOM)**

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|---|---|
| A03-080 | Small Multi-decade Communications and Electronic Warfare (EW) Antenna |
| A03-081 | Blockage Mitigation Techniques for On-the-Move Satellite Communications |
| A03-082 | Extensible Markup Language (XML) Compression Tool |
| A03-083 | Military 3-D Visualization Utilizing Gaming Technology |

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| A03-084 | Ultrafast Charging of Smart Lithium Ion Rechargeable Battery Hybrid Power Sources |
| A03-085 | Lithium-Air Technology |
| A03-086 | Commanders Portal Technology |
| A03-087 | Use of Cognitive Systems in Generation of Course of Action |
| A03-088 | Near-Real Time Tactical Automated Machine Translation Technology(N-TAMTT) |
| A03-089 | Integrated Search and Discovery Portal |
| A03-090 | Techniques for Unconventional Terrain Navigation |
| A03-091 | Command and Control Metrics |
| A03-092 | Advanced Monostatic and Bistatic Azimuth Estimation Techniques |
| A03-093 | Video-Moving Target Indicator (MTI) Trackers for Multiple Targets |
| A03-094 | Knowledge Engineering Environment for Army Intelligence Analysis and Interpretation |
| A03-095 | See Thru the Wall Technologies |
| A03-096 | Perimeter Detection System |
| A03-097 | All Terrain Combat Identification |
| A03-098 | Wind Blown Clutter Reduction to Improve Ultra High Frequency (UHF) Moving Target Indicator (MTI) Performance |
| A03-099 | Selective Localized Global Positioning System (GPS) Denial |
| A03-100 | High Speed, High Power, Electronically Tuned Components |
| A03-101 | Low Probability of Intercept/Low Probability of Detection (LPI/LPD) and Radio Frequency Interference (RFI) Mitigation Techniques |
| A03-102 | Global Positioning System (GPS) Interference Electronic Support Measure (ESM) Payload for Unmanned Aerial Vehicles (UAVs) |
| A03-103 | Low-Loss Synthetic Aperture Radar (SAR) Data Compression |
| A03-104 | Low Cost Three Dimensional Laser Radar Receiver |
| A03-105 | Optical Components to Reduce Retroreflection from Uncooled Infrared Focal Plane Array |
| A03-106 | Uncooled Infrared (IR) Camera with High Resolution Zoom |
| A03-107 | Landmine Detection |
| A03-108 | Off-Route Mine Detection |
| A03-109 | Detection of Non-buried Explosives using Chemical Detecting Technologies |
| A03-110 | Lightweight Laser Designator |
| A03-111 | Near Infrared Streak Tube |
| A03-112 | Security for Wireless Handheld Devices |
| A03-113 | Terrain Aware Network Planning Tools |
| A03-114 | Network Protocols for Onboard Satellite Packet Routing |
| A03-115 | Small, Bandwidth Efficient Satellite Communications Modems and Waveforms |
| A03-116 | Satellite Access Using Unmanned Aerial Vehicles |
| A03-117 | Disposable Micro-Radios for Sensor and Munitions Networks |
| A03-118 | Digital Dynamic Pre-Distorter for High Power Amplifiers for Wideband Digital Radios |
| A03-119 | PAMELA: Propagation Analysis and Modeling Experiments for Laser Applications |
| A03-120 | Smart Single or Multiple Beam Forming Antennas in the 1 to 2 GHz Range |
| A03-121 | Networked System on a Chip for C4ISR |
| A03-122 | Orthogonal Coding for Code Division Multiple Access (CDMA) |
| A03-123 | Disposable Imaging Sensors |
| A03-124 | Automated Wafer Polishing for Epi-ready CdZnTe Substrates |

**Edgewood Chemical Biological Center (ECBC)**

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| A03-125 | Carbon Nanotube Obscurants for Survivability |
| A03-126 | Multi-Dimensional Separations Technology for Proteomics |

**Engineer Research & Development Center (ERDC)**

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| A03-127 | Buried Mine/Unexploded (UXO) Detection and Identification Improvement Through Characterization and Innovative Incorporation of Sensor Background Noise/Clutter Signals |
| A03-128 | Implementation of a Geospatial 3-dimensional Topology Model |

A03-129 Spatial Data Mining
A03-130 Sensors for Rapid Chemical Biological Radiological (CBR) Detection and Countermeasure Activation to Protect Water Distribution Systems
A03-131 Immunological Detection of Pathogens by Biofunctional Membrane
A03-132 Modeling and Simulation of Chemical and Biological Agents in Potable Water Systems
A03-133 Geospatial Exploitation of Motion Imagery (GEMI)

A03-134 Dendrimers for Biological Warfare Agent Detection and Neutralization for Immune Buildings
A03-135 Urban Tactical Decision Aids
A03-136 A Device for Estimating Site Condition
A03-137 Void Detection and Stiffness Measurement System for Road and Airfield Pavements

**Missile RD&E Center (MRDEC)**

A03-138 High Temperature Matrices for Filament Wound Composites
A03-139 Robust Alignment Concepts for Precision Guided Weapons
A03-140 Fabrication Enhancements for the Production of Spinel Domes
A03-141 Thermobaric Blast Pressure Gauges
A03-142 Weapon Weight Reduction Using Genetic Algorithms
A03-143 Rocket Exhaust Plume Secondary Smoke Formation Modeling
A03-144 Nanograin MgF2 for Tri-Mode Seeker Dome
A03-145 Weather Encounter Particle Impact Phenomena and Failure Criteria for Missile Components
A03-146 Coating Applications of Single Wall Nanotubes
A03-147 Impedance-Based Structural Health Monitoring
A03-148 Hypersonic Material Technology for Missile Components
A03-149 A Throttling Solid Propellant Rocket Motor with Adaptive Thrust Control
A03-150 High Speed X-Band Single Pole 4 Throw Switch
A03-151 Diode-Pumped Solid-State Laser (DPSSL) for Airborne Laser Radar
A03-152 A Logistic Regression Model for Single Shot Missile Reliability Prediction
A03-153 Advanced Gel Propellent Fuel
A03-154 Advanced Gel Bipropulsion Tank System

**Medical Research and Materiel Command (MRMC)**

A03-155 Development of Medic Blood Pack
A03-156 Skeletal Muscle Water Content Measurement Sensor/Tool
A03-157 Generic Flavivirus-Based Vaccine Platform for Biological Threat Agents
A03-158 Enhanced Detection and High-Throughput Screening of Proteomic Signatures/biomarkers in Neoplastic Tissue
A03-159 Personal Area Network for Warfighter Physiological Status Monitoring (WPSM)
A03-160 Biomonitors for Real-Time Air Toxicity Monitoring
A03-161 Integrated Architecture for Functional Genomic Measurements
A03-162 Haptics-Optional Surgical Training System (HOSTS)
A03-163 Re-Usable Intraosseous Infusion Device
A03-164 Diagnostic Microarray Test Based on Comparative Studies of Gene Expression in Humans with Common Inflammatory and Infectious Diseases
A03-165 Accelerated Drug Design Through Computational Biology
A03-166 Development of Bioassays for Prion Infectivity Using Human, Deer, or Elk Cells
A03-167 Innovative Manufacturing Techniques for Polysaccharide-Protein Conjugate Vaccines
A03-168 Anti-Microbial Nanoparticles Composed of a Magnetic Core and Covered with Photocatalytic TiO2
A03-169 Programmable Wrist-Worn Prediction Model and Environmental Stress Monitor
A03-170 Patient Safety Perioperative Readiness Support System
A03-171 Multimeric Protein Malaria Vaccine
A03-172 Angiogenesis Targeted Drug Development

A03-173 Amplification of Proteins in Body Fluids for Early Detection of Biological Warfare Exposure
A03-174 Advancing Training Techniques of Non-Invasive 3-Dimensional Ultrasound Sound Technologies for both Diagnostic and Therapeutic Applications
A03-175 Portable Test for Detection of Viruses in Arthropod Vectors
A03-176 A "Personal Blood Pack" to Improve the Availability of Red Cells for Transfusion during Contingency Operations
A03-177 Development of a Field Portable Mosquito Monitoring System with Attractant
A03-178 Noninvasive Treatment of Hemorrhagic Shock

**Natick Soldier Center (NSC)**
A03-179 Non-Ceramic Small Arms Protective Inserts in Personnel Armor
A03-180 Development of Stitchless Seaming Equipment
A03-181 Self-Decontaminating Barrier Material Incorporating Catalytically Reactive Membranes for Individual and Collective Protection on a Chemically/Biologically Contaminated Battlefield
A03-182 Individual Cooling Element (ICE) for Improved Warfighter Hydration
A03-183 Development of Silent Hook and Loop Closure System
A03-184 Modular Parachute Concepts
A03-185 Micro-Atomizing Logistic-Fuel Delivery System
A03-186 Hydrogen Capture or Utilization in Mg/Fe Based Chemical Heaters
A03-187 Medical Textiles
A03-188 Height Sensors and Velocity Sensors
A03-189 Tactical Guidance System for Military Free Fall
A03-190 High Performance Shelter Insulation with Reduced Weight and Cube
A03-191 Body Conformal Integrated Personal Area Network
A03-192 Active Package Olfaction to Increase Soldier Acceptance of Field Rations
A03-193 Rigidification of Flexible, Inflatable Composite Structures

**Space and Missile Defense Command (SMDC)**
A03-194 Enhanced Lethality Munitions for Army Applications
A03-195 Advanced Algorithms for Tomographic Imgaging
A03-196 Explosive Pulsed Power
A03-197 Engineering Models for Reactive Munitions
A03-198 Compact, Rugged Ultra Wideband Antennas
A03-199 Army Directed Energy Weapon Systems Deployability Enhancements

**Simulation, Training & Instrumentation Command (STRICOM)**
A03-200 Advanced Virtual Environment Haptic Simulation
A03-201 Automated Tool to Model Software for System Performance Predictions
A03-202 High-Precision, Expendable, Six Degree-of-Freedom Sensor
A03-203 Trainning Performance Assessments for Mixed Initiative (Manned/Umanned) Team
A03-204 Adapting Intelligent Tutoring System for Assessing Collaborative Skills
A03-205 Software Tools for Modeling Urban Details
A03-206 Common Aggregation Framework for Simulation Scalability
A03-207 Multi-Resolution Terrain Models Representation

**Tank Automotive RD&E Center (TARDEC)**
A03-208 Increased Plastic Oxygen/Water Barriers
A03-209 Lightweight Multi-Use Slipring
A03-210 Damage-Based, Low-Threshold Optical Attenuating Materials
A03-211 Low Cost Materials, Designs, and Manufacturing Processes for Robust Tubular Solid Oxide Fuel Cells (SOFC)
A03-212 Hydraulic Actuated Roll Inhibited Active Suspension for the Army
A03-213 Biofiber-Reinforced Structural Composites for Use in Matting/Temporary Roadway

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| | Panels |
| A03-214 | Portable Highly Mobile Autonomous Robot for Mine Detection |
| A03-215 | Enhanced Mobility for Small Vehicle Platforms |
| A03-216 | Command and Control of Small Tele-Operated Robots |
| A03-217 | Advanced Thermal Management of LEDs |
| A03-218 | MEMS/Smart Sensor for Hydraulic Fluidic Analysis |
| A03-219 | Intra Vehicle Adaptive Computing, Network Security, and Networking Using Ultra Wideband (UWB) Technology |
| A03-220 | Multiperspective Autostereoscopic Display |
| A03-221 | Replacement of CRT-Based Displays |
| A03-222 | Integrated High-Performance Remote Visualization Capability |
| A03-223 | Integration of Vehicle Models and Analytical Simulations |
| A03-224 | Development of High-Resolution Virtual Terrain for Use in a Motion-Based Simulator with an Image Generator |
| A03-225 | Computational Modeling of Nanostructures |
| A03-226 | Integrating Stochastic Engineering Models in a Distributed Environment |
| A03-227 | Exploratory Development for A Controllable Combustion Process for Improved Power-Density and Fuel Economy within Multi-Fueled, Low Heat Rejection Compression Ignition Engines |
| A03-228 | Passive Thermal Management for Next Generation Vehicles |
| A03-229 | Virtual Prototyping Vehicle Electrical System Management Design Tool |
| A03-230 | Transmission and Driveline Development and Their Components |
| A03-231 | Develop New Innovative Filtration Designs and Components for Improved Service Life, Performance and Durability |
| A03-232 | Point of Use Oil Quality Analysis |
| A03-233 | Advanced Military Diesel Engine Technologies |
| A03-234 | High Efiiciency, Compact Heat Exchanger for Mobile Equipment Applications |
| A03-235 | Next Generation Thermal Management Rapid Prototype Tool for Future Combat Systems (FCS) and 21st Century Truck |
| A03-236 | MEMS Smart Battery Monitoring System |
| A03-237 | Heavy Duty Vehicles Cold starting System |
| A03-238 | Low-Power, Compact Logistic Fuel Pre-Reformer |
| A03-239 | Development of An Underarmor 10 Kilowatt Thermoelectric Generator Waste Heat Recovery System for Military Vehicles |
| A03-240 | Water Production for Tactical Systems |
| A03-241 | Innovative Wet Gap Crossing Technologies for the Future Combat System/Objective Force (FCS/OF) |
| A03-242 | The Robotic Mule |
| A03-243 | Development of 15,000/30,000 BTU Multi-Fuel Fired Forced Air Heating System |

**ARMY 2003.2 SBIR TOPIC DESCRIPTIONS**

A03-001 TITLE: Generic Sensor Information Transmitter Optimized for Acoustics

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PM Close Combat Systems

OBJECTIVE: Develop an innovative generic sensor information transmitter for acoustics detection.

DESCRIPTION: The land acoustic development efforts have made significant strides classifying and tracking targets over large battlespace areas using multiple microphone beamforming arrays. The highest performance has been achieved with devices employing arrays of 8 microphones or more in circles of 12 ft diameter or more. Unfortunately, the cost to develop a unit consisting of a large number of microphones and with accurate placement has been historically unattractive. Most planned implementations have been compromises employing modest sized arrays with 5 microphones or less, with projected development costs still high. An innovative approach is possible to break the paradigm. This SBIR technology is looking to optimize the functional combination of input signal feature extraction with data compression in order to achieve very high total compression ratios of the input acoustic signal in order to achieve significantly greater target detection performance at appreciably lower costs. The realization of total compressions ratios in excess of 50 to 1 (with goal 100 to 1) allows a practical, low cost means to directly transmit the essential raw acoustic signal from remotely deployed sensors to a remote master computer. With such an approach, an entirely different system solution is possible. Instead of deploying large devices with cumbersome multiple microphone fixtures and high cost custom processing electronics, it would be possible to seed a surveillance area with a modest quantity of single microphones containing low cost, small sized generic "sensor information transmitters". Significant system level performance gains are possible as a result of the freedom with which a "master" computer can analyze the essential attributes of all raw sensor data within the surveillance area. The implementation of higher performance system level beamforming using strategic combinations of the remotely deployed sensors allows greater detection ranges, better multiple target discrimination, more accurate target tracking, and system solutions which can be customized to a particular surveillance application.

PHASE I: Design and optimize innovative solutions for acoustic signal feature extraction in functional combination with state-of-the-art compression schemes (lossy, lossless, or integrated) optimized for the transmission of essential acoustic feature information while maintaining a high level of beamforming performance after signal de-compression. Total compression gains desired are in the range of 50-100.

PHASE II: Develop a prototype generic processing board solutions, of approximately 2 inch square or less and 4 chips or less, offering quick transition to production. Provide interface from the compressed data output to an RS232 link for connection to GFE communications systems. Demonstrate the ability to transmit the raw acoustic signal from each sensor to a remotely placed master computer. Test system performance using GFE acoustic target tracking and classification algorithms.

PHASE III DUAL USE APPLICATIONS: Small, low cost "sensor information transmitters" can be easily optimized for a wide range of sensor types and obviate the need for custom sensor on-board processing solutions at the sensor node level. Once the "generic front end electronics" is designed for a particular sensor type and optimized for a particular application, the device can be wirelessly linked to any standard computing platform to host the system level processing algorithms. The approach also promotes the proliferation of low cost, deployable sensors in support of targeting for FCS systems. DoD applications for ultra low cost, small size acoustic, seismic, and magnetic sensors include homeland security border patrol, base security systems, and to better promote mass scattered air-deployable surveillance/targeting sensors systems. Commercial applications include crowd control systems, home security systems, and traffic monitoring of autors or aircraft.

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2) K. Sayood. Morgan Kauffman, "Introduction to Data Compression", Second Edition, 2000.
3) A. Gersho and R. M. Gray, Vector "Quantization and Signal Compression", Kluwer Academic Press, 1992.
4) N. S. Jayant and P. Noll, "Digital Coding of Waveforms", Prentice-Hall, 1984.
5) R. M. Gray, "Source Coding Theory", Kluwer, 1990.
6) R. M. Gray, "Entropy and Information Theory", Springer-Verlag, 1990.
7) T. C. Bell, J. G. Cleary, and I. H. Witten, "Text Compression", Prentice-Hall, 1990.

KEYWORDS: acoustics, classification, tracking, feature extraction, signal compression

A03-002 TITLE: Recoil Energy Recovery for Powering Munitions

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and build an innovative system that converts the recoil G-Force of firing a projectile into powering the munition:

DESCRIPTION: The weapons of the future are no longer normal bullets or kinetic energy projectiles. Currently we are using sensors, seekers, electronic fuzing, and the road to directed energy projectiles is before us still. These systems need a sizable source of energy to function and the space consumed by large batteries is unacceptable for many applications. When these projectiles are fired, either from a tank gun, mortar shell, or rocket tube, they are exposed to G forces in excess of 18,000 Gs in a small fraction of a second. If this force can be converted into electrical energy and stored for a short period of time (10 minutes at the most), we could have more accurate and lethal projectiles.

The generated power should minimally operate the fire control and acquisition systems within that ?smart? projectile; and optimally provide Source Power for an onboard Directed Energy Projectile.

The system should be as small (volumetrically) as possible and have the potential to generate enough power to operate at least one device at 12v for a minimum of 3 minutes.

PHASE I: Design a system capable of taking a significant shock load and converting it into electrical energy. Perform trade-off analysis of size vs. power output and technical complexity/reliability.

PHASE II: Fabricate and characterize prototype device.

PHASE III DUAL-USE APPLICATIONS: In addition to military applications, any industry plagued with shock loading could benefit from the virtually free energy generated by phenomena that are already present. For example, in the case of Electric Vehicles, energy could be generated every time the vehicle hits a bump, the shock load is transferred from the wheels, creating energy to recharge the battery.

REFERENCES:
1) http://www.g2mil.com/155mortars.htm
2) http://www.dtic.mil/ndia/smallarms/Ernest-Jones.pdf

KEYWORDS: Power, Energy, Shock Loading, G Forces, Alternative Energy

A03-003 TITLE: Small Arms Gun Barrel Stabilization Using High Energy Density, Rugged, and Low Creep Actuators

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Individual Weapons

OBJECTIVE: To design and develop innovative high energy density, low creep actuators for small arms applications to compensate for combat induced stress related gun position jitter.

DESCRIPTION: In modern infantry combat soldiers are exposed to intense external stimulations generated by the effects of modern weapons including bright flashes of light, extreme loud noises, witnessing of severe injuries and loss of life, etc. It is well know that the stress generated by these combat experiences produces physiological effects that are detrimental to fine motor skill dependent activities such as marksmanship. For example, studies have shown that the heart rate of a soldier in combat can reach upwards of 300 beats per minute, well above the typical maximum of approximately 200 beats per minute experienced by elite athletes in competition. Additionally, both respiration rate and muscle jerk response increase. These well known physiological effects significantly degrade a soldier's marksmanship performance in terms of shot accuracy and dispersion which degrades mission effectiveness, increases collateral damage and civilian casualties and ultimately reduces soldier combat survivability.

Various strategies have been developed to mitigate these effects on the soldier including: a) physical conditioning to build-up and maintain gross motor skills, physical strength and stamina, b) mental conditioning to better enable the soldier to manage the psychological effects and c) rigorous marksmanship training including range and simulated combat exercises. However, these training regimes are costly, time consuming and have varying degrees of effectiveness, since it is virtually impossible to simulate the external stimulation and life threatening nature of actual combat.

Instead of the current approach described above, the U.S. Army is seeking the development of an innovative active gun barrel stabilization system including rugged, high energy density, low creep actuators to integrate into a small arms platform in order to decouple the stress related tremble or jitter imparted by the soldier to the weapon from the weapon gun barrel. The small arms stabilization system envisioned here would function in a similar fashion to that of optical stabilization systems found in many small handheld video cameras, i.e., rejecting "high" frequency jitter/tremble disturbances from the camera line of sight but allowing lower frequency camera pointing commands.

The target application for the effort here is the M24 Sniper Weapon System. This platform and the environment in which it must operate place many difficult constraints on the system design. For example, the stabilization system must be compact, lightweight, have minimal effect on weapon balance or feel, and fit into small spaces such as the gunstock. It must operate under harsh environmental conditions including high shock levels, cold and hot temperatures, water immersion, etc. Additionally, the system must be very reliable and if it fails must not effect the operation of the weapon.

The design of the small arms stabilization system contemplated here will likely require an integrated system of sensors, actuators, a processor and other electronics and a power source. Critical in this design effort will be the development of rugged, high energy density, low creep, and compact actuators. A comprehensive tradeoff analysis must be performed among the candidate actuator technologies in order to produce an actuator design that meets the significant constraints of the target small arms application. The desired (i.e., target) actuator specifications for effective performance are: -/+ 400 micrometer maximum azimuth/elevation displacement capability; force capability of 45 Newtons (10 pounds); frequency response of 0-10 Hz and physical envelope dimensions of 20mm x 10mm x 10mm. Explicitly delineate power requirements and schemes for minimizing both power load and weight/volume of power package.

PHASE I: Design a small arms gun barrel stabilization system.

PHASE II: Build a prototype of the small arms stabilization system.

PHASE III DUAL USE APPLICATIONS: For military application, integrate this technology into the M24 sniper rifle and test in a relevant environment. Through live fire testing, demonstrate improvement in bullet impact dispersion at various ranges. Through environmental testing, demonstrate system ruggedness and reliability; however, potential applications are not limited to munitions.

For commercial applications, cost effective, low creep actuators are needed in the aerospace industry, as well as in the vehicle industry. Stabilized platforms have broad applications in numerous commercial endeavors.

REFERENCES:

1) Siddle, Bruce K. Sharpening the Warrior's Edge, Millstadt, IL: PPCT Research Publications, 1995.
2) Marshall, S. L. A., The Soldier's Load and the Mobility of a Nation, The Combat Forces Press, 1950.
3) Grossman, D., & Siddle, B. K., "Psychological Effects of Combat," in Encyclopedia of Violence, Peace and Conflict, Academic Press, 2000.
4) FM 23-10 Sniper Training. Headquarters of the U.S. Army. Washington D.C. August 1994

KEYWORDS: actuators, weapon stabilization, gun barrel

A03-004 TITLE: Innovative Modular Packaging of Military Supplies

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and build modular packaging with features of biodegradability and impact mitigation capability for mixed classes of supply including ammunition to support various military missions.

DESCRIPTION: To support the future force in military missions, the logistics system must provide fast and accurate supplies to soldiers in order to enhance their operational efficiency in battlefield. Modular packaging is an excellent concept to help the Army to meet this objective. Furthermore, to increase the safety of ammunition handling and reduce environmental impact, the modular packaging should be fabricated with biodegradable materials with a novel internal packing material which is capable of insulating against high temperature and preventing munitions initiation from ballistic and fragment impact. The biodegradable materials should be lightweight, disposable, and relatively low cost. The proposed packaging must be capable to maintain a 3 pound per square inch (psi) seal and meet the rough handling requirements at ambient temperature as stated in the military packaging requirements as stated in MIL-STD-1904 including secured and loose cargo vibration and a three to seven foot drop test. The internal packing material should also be lightweight and low cost. In addition, it should be fire-resistant and impact-absorbing, with thermal insulating properties, and which can be made either electrically conductive or insulative. This material, such as carbon-based product would be applied or foamed into the interior of ammunition or missile containers to reduce the munitions sensitivity to bullet and fragment impact, and increase the time to reaction in cook-off events. The modular packaging should consist of a group of standardized modules consisting of at least three optimum sizes, large, medium and small. All modules will be used for shipping and storage of both solid materials including ammunition, and liquid materials such as water. The liquid modules should have an internal collapsible bladder with a self-contained extraction features with quick release couplings for transfer of liquid without the use of a pump. The loaded modules should be one man portable for small and medium modules and two men portable for the large one. A unit load can be built by using a combination of the standard modules to within a volume of 44 by 54 by 48H, occupying a quarter of a 463L pallet. Features to interlock one module to another and pallet components (top lift and base units) to modules are desired to provide a stable load. Minimizing or total elimination the use of banding is desirable. These features should be easy and quick to connect and disconnect. When a unit load is built using a combination of the standard modules with mixed classes of supply, it must meet the rough handling requirements as stated in the MIL-STD-1660.

PHASE I: Conduct studies and analysis to develop biodegradable packaging materials and impact mitigating internal packaging materials. Develop optimum standard sizes of modules and combinations of the modules to form a unit load within the volume as stated above. Design individual modular packaging to in accordance with military packaging requirements. Design self-contained extraction features (such as inflatable bladder) for liquid modules and easy connect/disconnect interlocking features to ensure a stable pallet load.

PHASE II: Upon successful completion of Phase I, develop and fabricate a prototype modular packaging system based on material and manufacturing process selected in Phase I. The material selected must be commercially available and the process developed be easily transitioned to high volume production. The prototype system will also be tested in accordance with Army's requirements, MIL-STD-1904 and MIL-STD-1660.

PHASE III DUAL USE APPLICATIONS: This system would have wide use in private sector to deliver products in a pre-packaged configuration such as medical supplies, video equipment, electronics, computer and food industry. Modular packaging would provide standardized modules common to all products including both liquid and solid. This concept will make handling, transportation and storage much more efficient and readily compatible to automation.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: ?????

REFERENCES:
1. MIL-STD-1904, Design and Test Requirements for Level A Ammunition Packaging
2. MIL-STD-1660, Design Criteria for Ammunition Unit Loads

KEYWORDS: Modular Packaging, Solid and Liquid Materials, Self-Contained Extraction Features, Innovative Interlocking Features, Easy Connect/Disconnect, Modules, ballistic shock mitigation, Pre-Packaged Configuration, biodegradable

A03-005 TITLE: Utilization of Acoustics and Laser Light for Energy and Power Transmission

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and build an energy/power transport mechanism using laser light and/or acoustics. This laser and/or acoustic source will transport the energy or power and deliver on target.

DESCRIPTION: Lasers and acoustics are used commercially for a number of different applications and one emerging technology/use is that of an energy transport mechanism. This technology permits the delivery of energy without the requirement that the laser source or acoustic element generate that power itself. This significantly reduces the size and weight of the laser source, reducing the need for large thermal management systems. It also provides the designer with a degree of latitude on the characteristics of the carrier beam to operate optimally in the prevalent atmosphere without sacrificing the properties of the energy to be delivered.

PHASE I: Investigate the possibility of using relatively low power lasers and acoustics to transport energy at range. Include discussions of the enabling technology, possible improvements to that technology, ranges expected, and amount of energy that can be reliably transported. Predict the behavior of both technologies and down select to the optimal transport mechanism (laser, acoustic, combination) for Phase II and support that decision.

PHASE II: Fabricate and characterize prototype device.

PHASE III DUAL USE APPLICATIONS: A number of commercial applications, including any that require rapid set-up or breakdown of operations, remote test sites, or command centers. Also could be used for non-explosive demolition work, remote drilling, or heating.

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5) Stability of the P to S energy ratio in the diffusive regime, Leonid V. Ryzhik, George C. Papanicolaou and

Joseph B. Keller. Bulletin of the Seismological Society of America, 86, (1996), pp. 1107-1115. Erratum. Vol. 86, (1996), p. 1997.
6) Transport Equations for Waves in a Half Space, Leonid V. Ryzhik, Joseph B. Keller and George Papanicolaou. Communications in Partial Differential Equations, 22, (1997), pp. 1869-1910.
7) Transport theory for acoustic waves with reflection and transmission at interfaces, G. Bal, J.B. Keller, G. Papanicolaou and L. Ryzhik. Wave Motion, 30, (1999), pp. 303-327.
8) Probabilistic Theory of Transport Processes with Polarization, G. Bal, G. Papanicolaou; To appear in the SIAM Journal on Applied Mathematics.

KEYWORDS: LASER, Energy Transport, high power, Directed Energy

A03-006 TITLE: Innovative Long Life Power System/Battery Recharge System for Munitions

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO - Ammunition

OBJECTIVE: Develop an innovative small energy scavenging system no larger than the size of a AA battery in volume, to power or recharge 3.6 V batteries used on asset visibility, prognostic-diagnostic sensing and robotic systems.

DESCRIPTION: This technology would enable prolonged use of battery-powered devices, extending operational life and shelf life, and reducing or eliminating costly battery replacement maintenance cycles. The increased operational life would be especially helpful in supporting prolonged operation in remote or hostile locations typical of the modern battlefield. (Afghanistan, Bosnia, SWA, etc.)

This new technology would support and enhance munition asset visibility and prognostic-diagnostic systems currently under development. These systems will allow more rapid and accurate location of items and assessment of materiel condition to accelerate delivery of critical munitions throughout the logistics system on a moments notice in support of short re-supply cycles.

The system design should provide at least 3 amp-hrs of energy over 15 years to extend the life of initial power sources/batteries. It must be capable of operating in explosive environments and comply with Hazards of Electromagnetic Radiation to Ordnance (HERO) standards. It must be operational between ?65F to +190F and withstand shock and vibration incident to infrequent off-road transit by tactical vehicles. Approximately 95% of the lifecycle will be spent inside dark munitions storage structures with average daily temperature fluctuations of 3 to 10 degrees. Therefore, harnessing this modest daily thermal fluctuation is likely to be the primary opportunity available in the absence of mechanical energy associated with infrequent transportation of the device.

Ideally the manufacturing will cost no more than approximately $5 for quantities of approximately 10,000. The device must be highly reliable and able to be integrated in a package roughly the size of a deck of playing cards.

PHASE I: Design a system capable of extending the life of rechargeable lithium batteries and/or powering munition asset visibility and prognostic-diagnostic sensor devices.

PHASE II: Fabricate prototype and demonstrate proof of principle in a laboratory environment using actual munitions prognostic-diagnostic sensors and asset visibility devices.

PHASE III DUAL USE APPLICATIONS: The technology/system developed could extend the life of a wide variety of items used in the commercial shipping, automotive and aerospace industries, as well as in numerous consumer goods. For example, literally hundreds of millions of battery powered smoke detectors and utility meters in use across the country could benefit. Tremendous cost savings would be realized through reduced or eliminated battery maintenance and increased operational life. Powering non-munition related items within the military is possible as well. Examples include advanced robotic applications, monitoring medical and food supplies and tracking replacement part shipments.

REFERENCES:
1) RRAPDS Environmental Sensor Overview & System Demo
2)https://w4.pica.army.mil/asis/RRAPDS-WebJune01_files/frame.htm
Thermoelectric generators:
3) http://www.hi-z.com/
4) http://www.dts-generator.com/

KEYWORDS: Electronics, microelectronics, sensor, prognostics, asset visibility, FCS, Objective Force, reduced logistics footprint, reduced life cycle costs, optimize resources, enhanced re-supply, lethality, enhanced survivability

A03-007 TITLE: Nano-Particle Surface Tension Release by Laser Initiation

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and fabricate a system capable of initiating the surface tension energy in nano meter size particles using lasers.

DESCRIPTION: Particles of exceptionally small diameter (10 nm – 1 micron is size) not only store a bulk energy due to their composition. They also contain surface tension energy inherent to their geometry. This surface tension energy (energy/surface area) is greater at that size given that the surface area continues to get smaller and smaller as the diameter reduces. At extremely small particle sizes the bulk begins to flow as a fluid and begin surprising us as to the amount of energy the particles can provide. There has to be a way to characterize the energy within the surface as given by the chemical composition of the particle, how it was formed and under what conditions, and the geometry of the particle to determine the total energy present in the particle. The technology would then be applied to energy storage, explosive enhancement, and aerosol cloud ignition for FCS self-protection.

PHASE I: Investigate the possibility of using a laser to extract and determine the surface tension energy of a nano-particle. Provide trade-offs of laser power, particle size and the amount of energy extracted. Provide findings and demonstrate the concept in a laboratory setting.

PHASE II: Design and fabricate a system capable of extracting and determining the surface tension energy with a laser and provide to the ARDEC for testing and evaluation.

PHASE III DUAL-USE APPLICATIONS: In addition to military applications, this technology has applications in the realm of particle manipulation for use in high power capacitors, designer explosives, particulate fuels, and pharmaceuticals.

REFERENCES: http://www.microperforation.com/page3.htm
http://www.wcsscience.com/surfacearea/andtemperature.html
http://www-ics.u-strasbg.fr/~mecapol/Mecanique_Physique/Introduction/PDF_files/Cavitation_Models.pdf

KEYWORDS: Laser, Initiation, Nano, nano-particles, surface tension force

A03-008 TITLE: Innovative Onboard Angular Orientation Sensors

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: PM Arms (OPM-CAS); PM Abrams

OBJECTIVE: To develop innovative onboard angular orientation sensors for munitions as alternatives to rate gyros and GPS for low cost integration into the next generation of smart munitions.

DESCRIPTION: Innovative onboard orientation sensor technologies are sought for munitions and other similar angular orientation measurement applications as alternatives to rate gyros, GPS and other similar sensors. The primary goal is to develop angular orientation sensors that could be used onboard munitions to provide full angular orientation information relative to a ground or base reference. The sensory system must be autonomous and must not acquire the sensory information through communication with a ground or airborne source. Sensors that can be embedded into the munitions structure and occupy minimal added volume are highly desirable. Precision, direct and stable measurement of angular orientation is critical for guidance and control of smart munitions. The proposed sensors must provide angular orientation with accuracy of around 0.1 milli-radians, must have negligible drift over several minutes of operation, must be capable of withstanding the harsh firing environment, such as temperatures of around 1200 deg. F and pressures of around 85,000 psi during firing, and very high accelerations of sometimes in excess of 100,000 Gs. This research will transition as a system solution applicable to direct fire munitions and indirect fire munitions where the exit, initial velocity and pitch, yaw and roll information are needed to compute a munitions trajectory. The exit initial conditions are needed for IMUs to calculate the trajectory needed for guidance and control. The design should address the issues of angular measurement accuracy, sensitivity, computational algorithms for angular orientation calculations, susceptibility to environmental noise and methods of reducing their effects, optimal design of the proposed sensors through modeling and simulation, methods of integrating the sensor into munitions and weapon platforms, methods and algorithms for processing the sensory signals, and methods of enhancing the performance of the sensor using signal processing and/or other hardware or software means. The primary trade-off parameters are size, cost, power consumption and accuracy.

PHASE I: Design an innovative onboard angular orientation sensor system for munitions as an alternative to rate gyros and GPS for low cost integration into the next generation of smart munitions.

PHASE II: Develop and fabricate a prototype of the proposed sensor system.

PHASE III DUAL USE APPLICATIONS: The development of direct and absolute angular orientation sensors has a wide range of military, homeland security and commercial applications. In the military related areas, such sensors, particularly if they are low cost, are essential for guidance and control of all smart munitions, missiles and guided bombs. These sensors are also essential for the development of guidance and control systems of various weapon platforms, robotic systems, particularly those used for remote operation in hazardous environments which may be encoutered in homeland defense. Commercial applications include testing and validation systems such as those used in simulators.

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4) Coplanar Waveguide Circuits, Components, and Systems Rainee N. Simons Book;2001;ISBN 0-4711-6121-7; Product No.: PC5948-TBR
5) A Coplanar Waveguide Bow-Tie Aperture Antenna,G. Zheng, A. Elsherbeni, C. Smith, University of Mississippi, USA
6) Synthesis of Irregular Waveguide Field Transformation Elements using a Multi-Resolution Algorithm, M.-C. Yang, K. Webb, Purdue University, USA
7) Modeling of Mode Excitation and Discontinuities in PBG Waveguides, F. Capolino, D. Jackson, D. Wilton, Univesity of Houston, USA
8) Folded Coplanar Waveguide Slot Antenna on Silicon Substrates with a Polyimide Interface Layer,A. Bacon, Georgia Institute of Technology, G. Ponchak, NASA, J. Papapolymerou, N. Bushyager, E. Tentzeris, Georgia Institute of Technology, USA

KEYWORDS: Affordable sensors for future Armaments, sensors to determine angular orientation, position, coordinate reference system, minimal real estate, low probability of detection

A03-009 TITLE: Mass Fabrication of MEMS-based Micro Detonator Technology

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: OICW STO Manager, Joint Service Sm Arms Prog Ofc

OBJECTIVE: Design an innovative, lightweight, compact, low power, low cost, MEMS-based micro detonator.

DESCRIPTION: Detonators have been successfully micro miniaturized to electrically initiate a weapon's firing sequence. The very small size of a micro detonator may facilitate the use of additional energetics to enhance lethality; or, may facilitate the integration of 'smart fuzing' within the warhead. Smart fuzing increases munitions lethality significantly. Recent advances in micro-machined silicon techniques demonstrate the capability for low-cost integrated micro cavities with a high degree of isolation, leading to the fabrication of wafer-based micro detonators that are extremely dense. The resulting micro detonators can be self packaged when separated from the wafer. This technology provides the potential for very low cost, very inexpensive, small, compact detonator components. This topic encourages new and novel mass fabrication approaches to micro detonator devices using micro-machining integration. Proposed components that include low temperature polymers and which exploit the unique capabilities of low voltage (1-3 DC) activation, particularly with secondary energetics, are sought under this topic. The MEMS-based micro detonator should be compated, 2 to 5 mm's squared, low power less than 200 micro-watt, and low cost (approximately 20 cents per detonator). For mass fabrication it is envisioned that 300 micro cavities be loaded and sealed simultaneously on a 4-inch silicon wafer.

PHASE I: Design a MEMS-based micro detonator that can demonstrate the feasibility of mass fabrication.

PHASE II: Develop a prototype MEMS-based micro detonator for mass fabrication.

PHASE III DUAL USE APPLICATIONS: The micro detonators will be applicable for use in military applications for medium-caliber air bursting munitions, landmines and demolitions, and commercially for anti tamper applications to protect microelectronics from unwanted exploitation.

REFERENCES:
1) Cooper, Paul W., Explosive Engineering,Wiley-VCH Inc. 1996 Chapter 24.

KEYWORDS: Energetic Deposition; Mass Fabrication; Low Temperature; Polymers; Low Voltage;

A03-010 TITLE: Advanced Multi-Sensor Array System (AMAS)

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: PM Close Clombat Systems

OBJECTIVE: Design, build, and test an Advanced Multi-sensor Array System (AMAS) using innovative noise reduction techniques, wherein magnetometer array sensor data is fused with acoustic array sensor data. AMAS shall detect and track ferromagnetic vehicles at very long range.

DESCRIPTION: During the last three years, the Army has been developing short-baseline solid-state magnetometer array (magnetic gradiometer) sensor systems for the real-time detection and tracking of armored vehicles. Since development has been focused on applications to anti-tank landmines (area denial), magnetometer array dimensions (baseline) have been constrained to match the outer dimensions of landmines.

This developmental experience has shown that the maximum detection and tracking ranges of short-baseline solid-state magnetometer array sensor systems are severely limited by noise. If detection and tracking ranges of landmine-sized magnetic gradiometers are to be significantly increased, it is imperative that innovative noise reduction techniques be explored, such as: low-noise electronics, real-time noise suppression signal processing, and post-deployment array baseline expansion. Recent experiments have also shown that when target data from a simple and inexpensive acoustic array sensor system are fused with magnetic gradiometry, not only can more accurate and more reliable real-time tracking performance be obtained, but also detection and tracking ranges can be extended.

AMAS shall significantly increase the maximum detection and tracking ranges of short-baseline magnetic gradiometers by incorporating innovative noise reduction techniques and data fusion with an inexpensive and simple acoustic array. AMAS magnetometers shall all be low-cost solid-state magnetometers.

When AMAS is eventually militarized and inserted into a munition, it will be completely self-contained (in the pre-deployed state) within the munition; however, for this SBIR, AMAS shall have all non-deployed components (except for its laptop computer operator console and power supply, as will be described) inside a vertical cylinder, five inches in radius and ten inches in height.

AMAS shall perform real-time detection and tracking, at 15 – 20 samples per second, of a main battle tank (MBT) moving at 60 kilometers per hour in the horizontal plane. MBTs of interest are those that the US Army may encounter in future battles; however, for the purposes of this SBIR effort, this MBT shall be defined to be an M1 Abrams. The AMAS magnetic gradiometer alone (without acoustic data fusion) shall: detect a moving MBT at a range of 60 meters; and track it (in range and bearing) up to a maximum range of 30 meters, with RMS tracking errors of plus or minus 15 degrees in bearing, and plus or minus 15 % in range. AMAS (with acoustic data fusion) shall: detect a moving MBT up to a maximum range of 300 meters; and track it up to a maximum range of 60 meters, with RMS tracking errors of plus or minus 3 degrees in bearing, and plus or minus 10 % in range. In addition, the AMAS shall estimate the target's magnetic moment vector with an accuracy of plus or minus 10 percent.

The reference coordinate system to be used in all measurements, calculations, and data inputs/outputs is the X, Y, Z coordinate system; where X is the north direction component, Y is the east direction component, and Z is the downward vertical direction component.

The AMAS shall be operated from a laptop computer operator console. Via this console, the AMAS operator shall be able to: start/stop data collection; select all AMAS modes of operation; select all AMAS parameters; initiate target-tracking algorithms (in both real-time and post-processing modes); display the target track and estimated target magnetic moment vector; and record all sensor data and tracking data.

The electrical power source of AMAS shall be dual mode: internal battery power, able to fully power AMAS for up to eight hours without recharging; and external power, able to utilize commercially available 115 volt/60 Hz electrical power. Battery recharging circuits shall be part of AMAS.

PHASE I: Develop the AMAS design. Perform all experiments required to show that the design shall meet the specified AMAS performance requirements for detecting and tracking the MBT. Specify all components. Specify all component performance parameters. Show origin of all component performance parameters by internal experiment reports, by published papers, by journal articles, etc. Analyze all sources of noise, including sensors, electronic circuits, and geomagnetic, to determine the resultant RMS noise to be expected in individual magnetometer outputs. Analyze the AMAS design to show that all performance requirements will be met.

PHASE II: Develop a prototype of the AMAS system.

PHASE III DUAL-USE APPLICATIONS: AMAS would have wide utility in civilian applications such as: homeland security applications including perimeter protection, airport security, and firearms detection; archeological surveying; and de-mining (UXO) applications.

REFERENCES:

(1) W. Michael Wynn, “Detection, Localization, and characterization of Static Magnetic-Dipole Sources,” in “Detection and Identification of Visually Obscured Targets,” edited by Carl E. Baum, published by Taylor & Francis, 1999.

(2) Czipott, Peter V.; Perry, Alexander R.; Whitecotten, Brian R.; Dalichaouch, Yacine; Walsh, David O.; and Kinasewitz, Robert T.; “Magnetic Detection and Tracking of Military Vehicles,” 2001 Meeting of the MSS Specialty Group on Battlefield Acoustic and Seismic Sensing, Magnetic and Electric Field Sensors, 23 October 2001, Applied Physics Laboratory, Johns Hopkins University, Laurel, MD.

KEYWORDS: Sensors, magnetics, acoustics, landmines, UXO detection, sensor fusion, tensor magnetic gradiometry, tracking algorithms, signal processing, noise-suppression algorithms, and magnetometers

## A03-011 TITLE: Solar Power for Ground Munitions, Sensors, and Communication Systems

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: PM-Close Combat Systems

OBJECTIVE: Design, develop, and test a solar power source for ground munitions, sensors, and communication systems.

DESCRIPTION: Many modern ground based munitions, sensors, and communication systems require a large amount of power to operate. Since these systems are usually battery driven, they must operate on a frugal energy budget, and battery replacement is not always an option. To extend the operating lifetime in the field, new energy sources are needed to address the problem. One possible solution is to incorporate solar power to recharge batteries as an additional power source to significantly extend the operating lifetime. In addition, solar power may make it possible to operate more energy consuming devices, such as video cameras, over an extended period of time.

The solar power source shall be designed for an existing sensor system that is in the form of a cylinder with dimensions that are 14 inches high and 5 inches in diameter. Six to eight rod shaped legs shall be used to erect the cylinder vertically from a horizontal position on the ground. The power source shall include, but not be limited to, solar cells configured to the cylinder or the legs, non-rechargeable and rechargeable batteries, monitoring indicator/software, and associated electronic circuitry, including the power switching electronics between the non-rechargeable and rechargeable batteries. The solar power source shall be capable of providing a nominal voltage of 14 VDC, be capable of generating at least 5.18 W-hrs/day with 6 hours of sunlight/day, and have a nominal battery capacity of at least 13Ah at 15 mA. It shall also be designed to withstand 1300 G's deceleration upon impact with the ground. The solar power source shall be tested in conditions such as snow (3 inches), tree canopy shadowing, tall grass (12"), dust, solar shadowing from the erected sensor system and tree leafs, and variations from solar output due to the diurnal cycle and time of year. Also, the source shall not attract enemy attention. Therefore, a low reflectivity surface on the solar cells shall be utilized in the design.

PHASE I: Design the solar power source. Specify all components. Specify all components parameters. Estimate the performance of the solar power assembly under varying environmental conditions. Show that the design objectives can be met.

PHASE II: Develop a prototype of the solar power source.

PHASE III DUAL USE APPLICATIONS: The proposed solar source can be utilized by the civilian sector to provide remote power for homeland security applications such as perimeter protection. In the military sector, the proposed source can be used as a power supply for ground based perimeter protection and target acquisition.

REFERENCES:

1) D. L. Pulfrey, Photovoltaic Power Generation, Van Nostrand Reinhold Company, 1978.

KEYWORDS: Power, Solar Power, Photonics, Batteries

A03-012 TITLE: Remote Sensing of the Electro-Magnetic Potential of the Human Heart

TECHNOLOGY AREAS: Biomedical, Sensors

OBJECTIVE: Design and build a device that can remotely detect the electronic signature of the beating human heart. The device would be portable, preferably give range and direction of the signal, and be able to work in high electronic noise environments.

DESCRIPTION: Advances in electronic signal detection and filtering technology could make it possible to remotely detect the electronic signal given off by the beating human heart. The human heart has a specific electronic signature that could be detected by filtering out the noise using modern electronic filtering technologies. Uses of such a device are numerous. A handheld version could be used by a medic in the field to determine the heart rate of wounded soldiers. By further refining such a device to detect through walls and obstructions, it could be used by soldiers in urban environments to determine how many individuals are in a room that is about to be entered and cleared. The signature could be detected using active doppler radar to sense the movement of the heart. The use of MEMS devices (gyroscopic) could be incorporated into the device in order to minimize the size needed as well as provide a means of canceling the doppler noise effects from the relative movement of the soldier carrying the device. It is expected that the weight of the system be approximately 5 to 10 lbs. and that the sensing range should be between 20 and 50 feet. If the sensing range of the device can be increased, then it could augment other sensing devices such as infrared and light amplification. With a longer range capability, this technology can be used in a telescopic sight on small arms/rifles to detect where enemy soldiers might be hiding.

PHASE I: Develop and build a proof-of-principle device using breadboard components that would show that the concept is feasible.

PHASE II: Develop and demonstrate a prototype of the human heart sensor.

PHASE III DUAL USE APPLICATIONS: For military applications, it is expected that this technology can be incorporated into the gun sight of small arms. Commerciallly, this technology would have applications in the medical industry. It would also have applications in security/police forces for detection and surveillance of individuals.

REFERENCES:
1) http://www.biofind.com/business/opportunity_search_details.asp?OpportunityId=110
2) http://www.darpa.mil/DSO/thrust/sp/metaEng/quasar.html
3) E.F. Grenecker, "Radar Sensing of Heartbeat and Respiration at a Distance with Security Applications," Proceedings of SPIE, Radar Sensor Technology II, Volume 3066, Orlando, Florida, pp. 22-27, April, 1997.

KEYWORDS: Sensors, electrocardiogram(EKG), remote detection, tracking, surveillance, heart rate, heart rhythm

A03-013 TITLE: Medium Caliber Gun Barrel Bore Coatings

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop, demonstrate and validate a coating technique to apply advanced erosion resistant materials to medium caliber gun tubes.

DESCRIPTION: Current medium caliber (20mm to 40mm) gun tubes have chrome as a protective coating applied on bore surfaces via aqueous electrodeposition. Utilization of highly energetic propellants exposes the gun barrel to high flame temperatures and erosive gases. Micro-cracks and porosity in electrodeposited chromium allow hot propellant gases to reach and degrade the steel substrate resulting in severe reduction of barrel life and overall performance. Executive Order EO13148 requires the usage reduction of hexavalent chrome (primary element of electro-deposition) by 50% by 31 Dec 2006. Currently under development in the Army is a process known as Cylindrical Magnetron Sputtering (CMS-IM). This internally-magnetized (IM) coating deposition technique is known to produce high quality coatings where materials are highly adhered, fine grained, crack-free and fully dense. Traditionally perceived as a "line-of-site" technology, CMS-IM has made instrumental advances in applications of coatings to internal surfaces of cylindrical substrates. This process is better suited for larger bore diameters and has fundamental limitations in internal bore diameters smaller than 60 mm. There is a need to develop a technique to apply quality coatings to gun tubes with dimensions below 60mm (all medium calibers). Specific efforts will be concentrated on designing methods of surface cleaning and preparation. The developed deposition process would demonstrate an ability to produce uniform, well-adhered dry coatings to comply with existing medium caliber test protocol requirements. The technique should have the potential to develop a coating of tantalum or other protective coating in a thickness suitable to provide a gun tube bore service life superior to one of an electroplated chrome bore. Explosive bonding of tantalum has shown success in the M242 Bushmaster 25mm. Some issues remain, such as the high cost of the tantalum material and the softness of the unalloyed tantalum. For purposes of flexibility of manufacture, it is desired to seek processes that yield nominally equivalent or superior results.

PHASE I: Demonstrate the feasibility of producing novel coating materials and/or processes for erosion protection of medium caliber gun tube specimens under simulated exposure conditions. Common coating characteristics (i.e., uniformity, density, etc.) should be sufficient to maintain or exceed current system results.

PHASE II: Further develop, optimize and implement the approach developed in Phase I and demonstrate performance improvements by applying the developed coating technology to a full-scale gun tube. Emphasis should concentrate on designing methods to improve surface preparation and non-destructive evaluation (NDE) of the steel substrate.

PHASE III DUAL-USE APPLICATIONS: This protective coating technology will have multiple uses for both military and commercial applications. Any systems where steel tubes are exposed to a corrosive, wear or erosion environment will have applications for this coating technique and benefit from this development. Examples would include engine or hydraulic cylinders, exhaust components manufacturing technology where sliding wear or erosion are a problem. Marine environments should not affect this coating.

REFERENCES:

1) "Analysis of magnetron-sputtered tantalum coatings versus electrochemically deposited tantalum from molten salt", Surface and Coatings Technology 120-121 (1999), 44-52.
2) Tri-Service "Green" Gun Barrel, www.serdp.org/research/PP/PP-1074.pdf.
3) "Analysis of magnetron-sputtered tantalum coatings versus electrochemically deposited tantalum from molten salt", Lee, Cipollo, Windover, Rickard; Surface and Coating Technology 120-121 (1999) 44-52.
4) Ceramic Gun Barrel Liners, Retrospect and Prospect: Dr. R. Nathan Katz, Worchester Polytechnic Institute, see: http://users.wpi.edu/~katz/coverpg.html
5) Gradiated Gun Barrel Fabrication Process, see: http://www.zyn.com/sbir/sbres/sbir/dod/navy/navysb03-1-065g.htm
6) Systems Analysis Physical Vapor Deposition of Tantalum on Gun Barrel Steel, US Environmental Protection Agency, e-mail address: http://www.epa.gov/ORD/NRMRL/std/sab/ta_pvd.htm
7) R. A. Srinivas, M. Xi, Ming, B. Metzger, Z. Lando, M. Narasimhan, and F. Chen, Enabling and cost effective TiCl4 based PECVD Ti and CVD TiN processes for gigabit DRAM technology Source, Proceedings of SPIE - The International Society for Optical Engineering, v. 3883, 1999, p 137-147.
8) J. J. Hautala and J. F. M. Westndorp, Patent US 6,413860, Apr. 27, 1999.
9) R. N. Johnson, "ElectroSpark Deposition: Principals and Applications", Proceedings of the 45th SVC Technical Conference, April 13-18, 2002.
10) R. N. Johnson, "Electro-Spark Deposited Coatings for High Temperature Wear and Corrosion Applications", Elevated Temperature Coatings: Science and Technology I, N. B. Dahotre, J. M. Hampikian, and J. J. Stiglich, eds., TMS, Warrendale, PA, 1995, pp. 265-277.
11) Robert F. Lowey, Gun Tube Liner and Wear Protection, TPL, Inc Report Number TPL-FR-ER31, ARO Tech Report Number 39097.1-MS-SB2,
Contract DAAD 19-99-C-0002, 30 May 2002.

KEYWORDS: Erosion, Coatings, Chrome replacement, Gun tubes, Steel, Surface Preparation

A03-014 TITLE: Smart, Light Weight Electronic Pointing Device for Indirect Fire Weapons

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Mortars

OBJECTIVE: Develop and produce a highly accurate smart, small, lightweight Electronic Pointing Device (EPD) for indirect fire weapons.

DESCRIPTION: The EPD will support managing fires effects and provide digital displays of its status/condition for determining the weapon's tube azimuth with respect to north and elevation. The EPD will be capable of being fully warmed up/operational within 2 minutes without support items, e.g. spare batteries etc., for a 24 hour fire mission. Current artillery and mortar weapon “pointing devices” such as the M2 compass is too inaccurate or too heavy and very expensive. The electronic systems employ status quo electronic sensor technology and require costly support equipment (e.g. heavy batteries for power etc.). It is proposed to create a light weight autonomous digital pointing device using/uncovering alternative critical enabling technologies (e.g., interferometric fiber-optic gyroscope) that would replace current status quo pointing sensors being employed. The new battlefield pointing system must be smart, rugged, responsive, accurate and simple. Using smart technology the EPD must be able to detect very accurately tube azimuth with respect to north and elevation. The EPD will provide digital-reading outputs in mils. This is one of the primary problems whose solution will enable required accurate fire. To assure conforming operational performance, accuracy requirements, e.g., 0.5 mil, will have to be demonstrated. The new unit will have for the user system self-diagnostic fault protection/alert, battery condition capability and be operable by users of the current weapon. The sight unit must meet the associated environmental requirements, e.g., firing durability. It is desired that the unit can function autonomously. With this information the gunner can readjust the weapon to the target should either move during firing(s). The EPD will also provide the other incidental but necessary fire control capabilities, e.g., support massed area fires. The pointer system must provide rapid response in all kinds of battlefield environments to enable accurate shoot and scoot operations (e.g. mortars). The EPD will be employed by the host artillery/mortar system on a non-interfering basis. The unit is envisioned to be operable with the M224 (60mm), M252 (81mm), M120 and M121 (120mm) series mortars and M119, M198 towed howitzers. The new EPD will be capable of being introduced without causing interference to function of weapon parts, weapon operability, firing, and safety.

PHASE I: Develop methodology/design and implementation of a low cost EPD system, which will result in a state of the art system. The EPD fire control unit conceptual operational electronic capabilities will be defined and demonstrated in a bread board configuration.

PHASE II: The effort will focus on designing, fabricating and testing one EPD.

PHASE III DUAL USE APPLICATIONS: With appropriate modifications the EPD could accurately sense the azimuth with respect to north and elevation (tilt) of airplanes, ships, vehicles, buildings etc. This “sensor” could be a very compact electronic unit with a digital pointing and "level" output display. Avoided would be use of similar more expensive, larger, heavy pointing devices. A modified EPD could also provide direction in mils to a visible fixed reference point(s). Since it is compact, the unit's electronic location sensor and digital readout could be adapted for users of boats, and by bikers, hunters, surveyors, etc. where elevation and azimuth bearings to a known point(s) is required. With this information the distance to a point could be approximated. The observer's location could also be determined by triangulation if two bearing points are available.

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1) “Guidance, Navigation, and Control from Instrumentation to Information Management,“ Eli Gai, Journal of Guidance, Control, and Dynamics, Vol. 19, No. 1, pp. 10-14, Jan-Feb 1996.

2) “The Development of Modern Inertial Navigation Systems,” W.X. Fu and C.Rizos, Proc. 3rd Satellite Navigation Technology Conference, Sydney, Australia, 8-10 April, paper no. 11.

3) “Modern Navigation, Guidance, Control,” Ching-Fang Lin, Prentice Hall, 1991.
4) “Navy and Industry Investigate New Super-accurate Optical Gyros for Possible Use on Ballistic Missile Submarines,” Edward Walsh, Military & Aerospace Electronics, December 2001.

KEYWORDS: Artillery, electronic pointing device, indirect fire weapons, mortar, digital readings, self-diagnostics, interferometric fiber-optic gyroscope, links, weapon fire control, required operating characteristics, massed area fires

A03-015 TITLE: Advanced Neutron Source for Radiography & Tomography

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Close Clombat Systems

OBJECTIVE: Develop an innovative small electrically generated source of thermal neutrons meeting requirements for practical neutron radiography.

DESCRIPTION: Practical applications for neutron radiography require thermal neutrons (energy range approximately 0.01 eV to 0.5 eV) of flux density of approximately ten billion neutrons per second per steradian from a point source of less than two millimeters in diameter. Neutron generating tubes using deuterium-deuterium (D-D) and deuterium-tritium (D-T) reaction have been around for many years. Unlike neutron radioactive sources, neutron radiation exists only when the deuterium ions are accelerated when hitting the deuterium or tritium target. Hence, the tube’s advantages are: it can be turned on and off like an x-ray tube, deuterium is not a controlled substance, and the tubes can be small (less than 10 centimeters by 10 centimeters) and portable. The D-D reaction produces a 2.4 MeV neutron and the D-T reaction produces a 14 MeV neutron flux, both referred to as fast neutrons. Neutron radiography is best done using thermal neutrons, which can be created by moderating the fast neutrons emanating from the tube. Current neutron tube’s flux output is inadequate to provide the thermal neutron flux density required for practical radiography. This solicitation is for a point source of thermal neutrons of sufficient flux for practical neutron radiography, which, like the neutron tube described above, is small, portable and is not naturally radioactively generated. The source should include a hermetically sealed generating tube, power supply and controlling electronics, moderator, etc., necessary for a self-contained system. The proposed source should be compared with all advertised neutron tubes, highlighting why the proposed solution excels over others.

PHASE I: Design the advanced neutron source. Provide convincing argument, preferably through simulations, from theory in conjunction with empirical data, that it will meet the described performance parameters.

Phase II: Fabricate a fully operational neutron source that meets the requirements for practical neutron radiography.

PHASE III DUAL USE APPLICATIONS: Small intense neutron sources have hundreds of applications. Built appropriately, thousands of units would be readily sold and deployed into applications. Applications include neutron radiography for security screening, industrial inspection, and medical diagnostics. Neutron therapy applications exist. Intense portable neutron sources are the best tool for finding buried mines for the de-mining application.

REFERENCES:
1) WEB site: Products from Thermo MF Physics A-320-4P.htm
2) Technology Transfer Department, E.O. Lawrence Berkeley National Laboratory, MS 90-1070, Berkeley, CA 94720, (510) 486-6467 FAX: (510) 486-6457
3) NonDestructive Testing Handbook, 2nd Edition, Volume three – Radiography and Radiation Testing, American Society for Nondestructive Testing, 1985

KEYWORDS:
neutron source, neutron radiography, non-destructive testing, deuterium, tritium, neutron generatring tubes, thermal neutrons

A03-016 TITLE: Innovative Real -Time Titanium Manufacturing

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM XM777 Lightweight Howitzer

OBJECTIVE: To develop an innovative, robotic system for welding titanium for current and future Army requirements.

DESCRIPTION: The Future Combat System (FCS) initiative has significantly increased the need for titanium parts in/on weapon systems. Many of these titanium parts will have to be welded. The application of robotic gas metal arc welding (GMAW) to titanium is relatively new. In order to obtain welds that are of high quality, it is necessary to develop an adaptive control methodology for real-time control and monitoring of the welding process. This SBIR proposes the development of an adaptive control/arc monitoring system that will be applied to existing welding hardware. The system will be innovative and beyond the scope of what is currently available commercially. This real-time control/monitoring system will integrate gas quality control with adaptive controls such as vision or other sensors with the goal of adding these to existing commercial welding robotic hardware. The system will allow the user to both monitor welding variables (current, arc length, torch speed, etc.), and make critical changes to these variables during the welding process. Trade-off optimization models should be explored. Factors affecting gas quality such as oxygen content, hydrogen content and dew point should be part of these models, as well as factors dealing with current, arc length and torch speed. A relationship between these factors and the welding gas will be outlined and explored. Hardware and software requirements will be determined for the system, as well as the best method of integrating the gas monitoring system with the adaptive controls.

PHASE I: Design an innovative real-time integrated control/monitoring system for titanium welding.

PHASE II: Develop and demonstrate a prototype control/monitoring system for the arc welding of titanium.

PHASE III DUAL USE APPLICATIONS: Besides the military application for the future combat system, potential commercial applications include the aerospace and automotive industries.

REFERENCES:
1) The NIST Automated Arc Welding Testbed
http://www.isd.mel.nist.gov/documents/rippey/awms97.pdf
2) Development of Robotic GMAW Workcell for Fabrication of Ti6A1-4V Machine Gun Receivers.
http://www.titanium.org/PDF/Newsletters/March2002News.pdf
3) Common gun and torch questions for robotic welding.
http://www.binzel.com.au/binzel.nsf/edithints/CFF5F9C6B0104296CA256B7B001A1073/$file/Common%20gun%20and%20torch%20questions%20for%20robotic%20arc%20welding.pdf

KEYWORDS: Titanium, Welding, Real –Time, Future Combat System, Robotic.

A03-017 TITLE: Intelligent Agent Technologies for Homeland Defense

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: HomelandSecurity Office, Picatinny

OBJECTIVE: Develop algorithms, design methodology and processing architectures to support implementation of real time intelligent agent technology for coordinated, rapid information retrieval, fusion, and prediction of potential threats for Homeland Defense.

DESCRIPTION: The terrorist/ threat prediction process and generation of the common relevant operational picture (CROP), be it carried out by human analysts or an intelligent system, is very data intensive. The data are usually distributed across several services, multi-national forces and/or agencies and in various formats. The problem is how to automatically accumulate relevant data from such distributed and heterogeneous data sources so that minimal amount of time is spent in learning individual data formats. Intelligent agent technology can greatly enhance data retrieval efficiency by automatically locating and retrieving data based on user queries. Once the specific data sources have been located and retrieved, they need to be fused based on some standard ontology to support rapid situation and threat assessment and prediction.

The amount of relevant data that are being accumulated has become overwhelming. A manual analysis to look for indications and warnings of threats into such data is highly time consuming. Intelligent techniques therefore need to be employed that can automatically assess and predict threats in a timely manner. Such techniques should be robust in order to deal with uncertain and incomplete data.

Specific areas of research within intelligent agent technology for Homeland Defense include:

1) Retrieval of data from distributed heterogeneous data sources based on agent technology
2) Fusion of accumulated information
3) Situation and threat assessment based on artificial intelligence techniques that can deal with uncertain data, such as Bayesian belief networks
Prediction of terrorist activities preferably taken into account the spatial and temporal dimensions

PHASE I: Develop the methodology, computational approaches and architectural concepts to support design and implementation of real time intelligent agent technology for coordinated, rapid information retrieval, fusion, situation assessment, and prediction of potential threats for netted fires and Homeland Defense applications. Problem formulation should take into account heterogeneity and voluminous nature of distributed data sources. Phase I will also identify specific software development and design tools, provide preliminary concept definition and specification of implementation environment.

PHASE II: Develop a fully integrated design and prototyping environment to support generic intelligent agent technology for coordinated, rapid information retrieval, fusion, and prediction of potential threats for Homeland Defense. The environment will include components for information retrieval, fusion, situation assessment and prediction. Develop detailed agent algorithms, application scenario, and software prototype and evaluate via simulation. Optimize module algorithm design based on test data and provide complete documentation of algorithms and the architecture.

PHASE III DUAL USE APPLICATIONS: Militarily, this technology can also be applied to the FCS system. There are many dual use applications of such intelligent agent technology. For example in the law enforcement community, this research could be applied to money laundering and drug dealing arena. On the commercial side, this research is applicable to detect credit card and telecommunication fraud by collecting data from multiple corporate data sources. The research is also applicable to generate business intelligence by collecting and analyzing data available over the web.

REFERENCES: Das, S., Shuster, K., and Wu, C. (2002) "ACQUIRE: Agent-based Complex QUery and Information Retrieval Engine," Proceedings of the 1st International Joint Conference on Autonomous Agents and Multi-Agent Systems, Bologna, Italy (July).
Pearl, J. (1988). Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference. San Mateo, CA, Morgan Kaufman.

KEYWORDS: Intelligent Agents, Homeland Defense, Information Retrieval, Situation Assessment, Threat Prediction

A03-018 TITLE: Innovative High Resolution Thermal Imager with Small Optics

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Close Combat Systems

OBJECTIVE: Design and build an innovative, automated thermal-imager with 360° field of view (FOV) optics to provide instantaneous full horizon detection, location and tracking of multiple targets.

DESCRIPTION: An automated target detection, location, and tracking sensor is needed to provide situational awareness of battlefield activities for target detection. An 8 to 14 micron uncooled, infrared, focal plane array thermal imager with 640x480 pixel resolution has the potential to provide day/night detection of personnel, aircraft and vehicles even when camouflaged. The novel combination of this high-resolution thermal imager with 360° FOV optics are needed to provide accurate target bearing, temperature profiles, and rough order of magnitude target imaging which can aid classification, discrimination and identification of targets. Innovative new technologies are required to make the 360° FOV sensor practical for the battlefield. The new technologies should encompass low cost, small optical lenses as opposed to the current expensive germanium or gold components, while still maintaining the required signal intensity level. It is expected that the sensor will be integrated with other unmanned ground sensors automatically to cue the imager. Also, it is expected to be integrated with GPS and an electronic compass to resolute target locations in Latitude and Longitude. An Automated Target Recognition (ATR) algorithm will be developed that combines the temperature profiles and shape icons with acoustic, seismic and magnetic target features to significantly enhance the ATR capabilities of remote sensors. When combined with other unmanned ground sensors, the thermal imager can be more effective than existing sensors. The integrated prototype sensor will be demonstrated against personnel, vehicles and aircraft to determine its automated capability; the number, type, speed, and direction of travel, location; and characteristics of targets on the battlefield.

PHASE I: Design an integrated 640x480 pixel, high-resolution, 8 to 14 micron, uncooled thermal imager with 360° FOV optics.

PHASE II: Develop an integrated prototype thermal imager with 360° FOV optics.

PHASE III DUAL USE APPLICATIONS: For military applications, the research will determine if it is possible to mass-produce the IR reflective optics for less than $100 so they can be incorporated into the intelligent munitions system. This 360° FOV thermal imager can also 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, 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.

REFERENCES:
1) AFRL-IF-RS-TR-2001-211, Sensor Data Collection and Management over a WEB, McQ Associates, POC Russell Thomas.
2) Into the Woods: Visual Surveillance of Non Cooperative and Camouflaged Targets in Complex Outdoor Settings, Vision and Software Technology Laboratory, Lehigh University, POC Dr. Terry Boult.

KEYWORDS: thermal imager, uncooled IR focal plane arrays, image processing, ATR, target tracking and location, sensor

A03-019 TITLE: Artifact Free Tomographic Algorithms

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Close Combat - Mines, Countermines, Demol

OBJECTIVE: Develop new computer x-ray tomographic reconstructing algorithms which do not create artifacts in the images.

DESCRIPTION: Tomographic reconstruction techniques by computed tomography (CT) have been continuously improving over the last years, but all of the algorithms create artifacts. For instance, nearly all CT algorithms calculate the density of volume elements within the reconstructed volume using a back-projection process. In these algorithms the absorption of an x-ray passing through the volume is evenly attributed to all of the volume elements through which the x-ray passed. This calculation always predicts the wrong density (which is the primary source of the artifacts) for the volume elements, but is most severe and noticeable when a very highly absorbing volume element is adjacent to lesser absorbing elements. These artifacts are perceived in the tomographs as dark and light rays emanating off sharp edges of the reconstructed volume. This solicitation is for development of one or more algorithms which drastically reduces or eliminates all artifacts, including that just described. Previous works to reduce artifacts require a prior knowledge of the geometry of the object to be reconstructed. The proposals for this solicitation must be indifferent to the geometry of the object. They must be applicable to full body reconstruction using cone beam CT, that is, reconstruction of all adjacent volume elements throughout the entire object, as opposed to reconstruction volume elements in one or more isolated cross-sectional slices through the volume. Proposals must show that the author has in-depth comprehension of the cause of numerous kinds of artifacts and a description of why the proposed methods should eliminate such.

PHASE I: Using both real data from actual objects and phantom data, develop one or more algorithms that result in greatly reduced artifacts. Quantify the reduction in artifacts for the developed algorithms comparing them to one another and to existing published and commercial algorithms. For Phase 1, the algorithms need not calculate rapidly.

Phase II: Optimize the algorithms so that they can produce a full body tomographic 3-D reconstruction on serial processors ganged in parallel. Reconstruction time for a volume exceeding 1300 by 1300 by 1300 volume elements must be less than ten minutes, where the raw data is 1300 by 1300 pixels by 361 rotational views. Demonstrate and deliver operational and source code, which is sufficiently documented that a computer programmer unfamiliar with the code can modify and maintain it. The code must be tested against images of objects having sharp and dense edges and corners, such as steel bars and gears, where density variation factors are five or greater within three volume elements. The code must not produce noticeable artifacts of density greater than one tenth of one percent of the true volume element density.

PHASE III DUAL USE APPLICATIONS: Applications include all industrial computed tomography (CT) inspection applications, both military and commercial. CT applications include airport baggage inspection systems and medical diagnostic equipment. Artifacts are the bane of all CT systems, whether x-ray, neutron, acoustic, ultra-sound, or seismic. One or more algorithms which prevent artifacts from forming will have a marketplace in and for all such systems. For example, the government is currently purchasing thousands of CT systems for baggage inspection in airports. All of these systems suffer from such artifacts.

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KEYWORDS: Computer tomography, radiography, x-ray, NonDestructive inspection, baggage inspection, tomographic artifacts.

A03-020 TITLE: 3-D HyperSpectral Microbolometer

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a 3-D microbolometer in which each layer of the single MEMS device measures the IR energy within a different narrow spectral band.

DESCRIPTION: Uncooled microbolometers are used for infrared imaging. Current micro-bolometer pixels are mechanically situated in a single plane, with each pixel absorbing a broadband of infrared energy. This solicitation is for the development, design and fabrication of stacked layers of micro-bolometer pixels in a single chip in which each layer absorbs energy in a narrow infrared band and passes the remaining energy onto the layer below. The structure, as a whole, will measure the intensity of the infrared energy in narrow spectral bands for each picture element in the scene, i.e., the 3-D microbolometer structure will measure simultaneously the entire data cube, as it is called in the HyperSpectral industry. The number of spectral bands should exceed 63, the spectral resolution should exceed one tenth of a micron, the broad spectral region should be approximately 8 to 25 microns, the number of spatial pixels should be 256 by 256 or more, the response speed of the device (data cubes per second) should be greater than 20 cubes per second.

PHASE I: Design the 3-D microbolometer. Provide convincing evidence that the device can be realistically fabricated using available manufacturing technology. Provide convincing evidence that the device can acquire a HyperSpectral infrared image. Compare the device design to that of the best, most efficient, and fastest microbolometer designs then available. Provide evidence that the developer can produce at least a fully operational prototype device within the Phase II budget.

Phase II: Fabricate a self contained, fully operational 3-D microbolometer that includes all the electronics, power supplies, computational hardware, software, etc., to acquire HyperSpectral Infrared images.

PHASE III DUAL USE APPLICATIONS: HyperSpectral imaging has already been shown to have a huge military and commercial market. Applications abound in target acquisition, battlefield assessment, LADAR, missile guidance, non-destructive inspection, surveillance, medical diagnostics, chemical analysis, process control and many other fields. A device of the nature being solicited could be used wherever infrared hyperspectral imaging is appropriate. But such a device could outperform all others in terms of robustness, acquisition speed, and field hardening. These attributes are essential to many of the aforementioned applications.

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KEYWORDS: HyperSpectral imaging, thermal imaging, microbolometers

A03-021 TITLE: Innovative Automatic Warhead Optimization and Modeling

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Multi-Role ATD Manager, ARDEC

OBJECTIVE: Develop an innovative, semi-automatic warhead optimization and modeling system using hydrocode simulation with design sensitivity analysis and stochastic methods.

DESCRIPTION: There is a need to quickly develop and field new lightweight warheads for Future Combat Systems (FCS). Automatic optimization and modeling software is needed, but current optimizing is done with smooth continuous response functions. Warhead simulations, however, are based on complex hydrocode simulations that are subject to considerable numerical noise. These noises introduce errors in the simulations that are not physics based; they include errors in the calculated velocities, stresses and strains. Another problem with the noise is that it may cause the simulations to terminate prematurely. Additionally, simulations must be calibrated with respect to experiments that are also subject to many noise sources, ranging from manufacturing imperfections to test measurement uncertainty. Numerical noise can be greatly reduced by using analytical differentiation of the equations of motion through the process of Design Sensitivity Analysis (DSA). Noise can be reduced by improving the accuracies of the velocity, stress and strain predictions to be within 5% of the experiment. In simulations where the noise would cause the calculation to go unstable, these new techniques would enable the simulations to run to completion. The optimization process must be suitable for large numbers of design variables. Stochastic methods should also be used in this optimization procedure to account for simulation and experimental noise. Approaches for this might include an extension to Kriging methods that are used for fitting data subject to large amounts of noise. The resulting software system should be able to take a set of design requirements, search through an existing database for similar experimental results from previous tests and produce a candidate design with a minimum of user intervention (reduced from user manipulation during every 100 calculation cycles to near autonomous completion).

PHASE I: Design an automatic warhead optimization and modeling software. Demonstrate the ability to compute analytical derivatives of major warhead performance variables based on typical input design variables using DSA in hydrocode simulations. Use this procedure to automatically iterate for an optimal warhead design.

PHASE II: Produce a robust system for automatic warhead design.

PHASE III DUAL USE APPLICATIONS: In addition to military applications, design optimization using hydrocode simulation is done in many different industries ranging from car crash to metal forming to bird ingestion in jet engines.

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1) AIAA2000-4906, Design Sensitivity Analysis for Structures using Explicit Time Integration, D. Stillman.
2) ASME 2002 Symposium on Design Automation for Vehicle Crashworthiness and Occupant Protection, "Development of a Design Sensitivity Analysis Technique for Explicit Finite Element Software with Applications in Crashworthiness", D. Stillman. Current tools used with Explicit FEA showing brute force stochastic simulation:
3) http://www.easi.com/software/storm Kriging theory:
4) http://www.geomatics.ucalgary.ca/~nel-shei/lecture.htm Design Sensitivity Analysis:
5) http://www.ccad.uiowa.edu/focus/designopt/dsa.html

KEYWORDS: hydrocode, simulation, design sensitivity analysis, numerical noise

A03-022 TITLE: HyperSpectral Data Cube Processor

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Fabricate a computer processor which has the ability to process HyperSpectral Images in rates of 30 or more cubes per second.

DESCRIPTION: Hyperspectral images can easily exceed 100 MB in size, consisting of more than one hundred spectral bands and be greater than one million pixels. The images need to be calibrated, corrected and spectrally matched to known spectra. The results need to be output at video frame rates to common display devices as images. Current processors do not come close to such high processing rates. This solicitation is for the design and fabrication of such a device. Consideration will be given only to those proposals where it is clear that the Phase II effort will actually fabricate, test and implement the processor in a hyperspectral system.

Hyperspectral images can easily exceed 100 MB in size, consisting of more than one hundred spectral bands and be greater than one million pixels. The images need to be calibrated, corrected and spectrally matched to known spectra. The processing algorithms will include (a) large convolutions, which may run in parallel on all of the pixels; (b) possible spatial transformations; (c) scalar and vector products and differences; (d) table lookup; etc. The results need to be output at video frame rates to common display devices as images. Current processors do not come close to such high processing rates. This solicitation is for the design and fabrication of such a device. Consideration will be given only to those proposals where it is clear that the phase 2 effort will actually fabricate, test and implement the processor in a hyperspectral system.

PHASE I: Design the hyperspectral data cube processor. In order to meet the Phase II requirements, the design must build on prior techniques or technology. It is expected that the commitment for the fabrication of the ASIC will be completed in the first six months of Phase II. The contractor?s design must be evaluated by at least one external expert in the processor field and his results reported to the government.

PHASE II: Fabricate a self contained, working system which can be directly attached to HyperSpectral VIS-NIR Imager, Model 700, fabricated by Surface Optics Corporation, acquire hyperspectral images and display the analysis results.

PHASE III DUAL USE APPLICATIONS: HyperSpectral imaging has already been shown to have a huge military and commercial market. Applications abound in target acquisition, battlefield assessment, LADAR, missile guidance, non-destructive inspection, surveillance, medical diagnostics, chemical analysis, process control and many other fields. A device of the nature being solicited could be used wherever infrared hyperspectral imaging is appropriate. The device will outperform all others in terms of robustness, acquisition speed, and field hardening. These attributes are essential to many of the aforementioned applications.

REFERENCES:
1) http://www.aticourses.com/hyperspectral_imaging.htm
2) http://www.techexpo.com/WWW/opto-knowledge/IS_resources.html
3) http://www.surfaceoptics.com/

KEYWORDS: HyperSpectral imaging, parallel processors, data cube

A03-023 TITLE: Measurement of Career Leadership Performance

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Center for Army Leadership, CGSC

OBJECTIVE: To develop a measurement system for leadership performance of Objective Force Leaders that accounts for cumulative experiences in applicable career areas. Assessment approaches should use objective, unbiased measures of leadership and should be specific to a leader’s experience in positions of responsibility and types of career opportunities open to him or her. The product will be used to aid leader development in instituional, operational and self development. The product, when widely applied, will have secondary applications to screen for appropriate development tracks, to inform Army educational institutions about appropriate course timing and duration, and to set optimal assignment paths.

DESCRIPTION: Long-range measures of leadership performance are needed to understand the impact of leadership over time and at various points in one’s career. Measures will lead to feedback to guide the development of leaders. Measures will be applicable for self-development and for institutionally-directed education. The Army Training and Leader Development Panel Officer Study found that 'junior officers are not receiving adequate leader development experiences,' [junior officers] 'do not believe they are being afforded sufficient opportunity to learn from the results of their own decisions and actions,' and 'personnel management requirements drive operational assignments at the expense of quality developmental experiences' (ATLDP, 2000).

Leaders develop over time based on unintentional experience and intentional attention to needs and goals. Development occurs because of an integration of trial and error experience, education and thoughtful reflection, and observation of the good and bad examples of others. Change can occur suddenly and rapidly or continuously and steadily (Weick & Quinn, 1999). The pattern of change over time can be revealing about a leader. But the Army has no theory-based system of leader development based on change over time. More importantly, there is no adopted system to measure the types, frequencies, and qualities of experiences that influence leader development. The Army is different from most civilian organizations because it grows its leaders "from the ground up" and moves leaders through a series of assignments in which they can develop for subsequent positions of higher responsibility.

People will remain the centerpiece of the Army and growing leaders will be one of its most essential missions. Leaders will be relied on to out think and dominate adversaries by speed and decisive action. Objective Force leaders will require a collection of interpersonal, conceptual, technical, tactical, mental, physical, and emotional competencies and the ability to learn, be self-aware and adapt. These requirements need to mature earlier in leaders' careers. Leaders must grow with the positions they assume to fully anticipate the higher order effects of their actions (Objective Force, 2002).

Standard Industrial/Organizational methods of psychology could link measures of leadership performance to job requirements. However, traditional job analysis would be complicated in this application by the number of different positions and skill classifications. Costs for a thorough job analysis of Army leader positions that constantly change are prohibitive. Rigorous job analyses that represent a bottom-up approach are impractical. In the Army, as with many organizations, a great variability of job demands exists within positions of supposedly the same level of authority and responsibility.

In the absence of a rigorous job analysis, leader assessment tools are oftentimes based on leader attributes, rather than objective measures of behaviors and outcomes. These subjective measures are often one-shot, self-report measures that attempt to tap job-related constructs. Measures that capture leader performance for only one point in time are insufficient in the support of leader development. These snap-shots of attributes are limited in scope and do not provide the objective behavioral information needed for leader development. In addition, self-report measures may be subject to socially desirability and faking (Paulhus, 1986).

On the other hand, biodata measures (activities, accomplishments, experiences) may be sufficiently free of social desirability bias and faking to be applicable to a career-oriented measurement framework. Biodata measures might focus on unit ratings, awards, climate, morale, and retention or on individual experiences considered to be significant learning opportunities. Measures that address growth or development over a period of time or in stages are reasonable candidates to consider. Records of work assignments (McCauley, Eastman & Ohlott, 1995) and the development that results can provide a basis for identifying appropriate measures. Retrospective measures confirmed by outside sources may be suitable substitutes for longitudinal measures taken at time intervals. These are not practical for validation research and may be too limiting for career development. Analysis of actual leadership challenges and situations for an individual would provide insight into leadership beliefs, styles, and capabilities. Systems of measurement should be explored to consider the merits of alternate approaches [e.g., modification of receiver operating characteristic curves (ROCs) from signal detection theory [Swets, 1964], personal strategies for leveraging talents and compensating for weaknesses, biodata (Mael & Schwartz, 1991), measures of variability such as Weiss & Shanteau's index of consistent discrimination variability (CWS), and so on].

PHASE I: Phase I will produce a framework for measurement and theory building or application, selection of measurement concepts, and demonstration of proof of concept. Models of leader work experience and event-based situations shall be a fundamental aspect of the measurement framework. Measurement or characterization of multiple leadership performance instances shall be intrinsic to the concept. Profiles of measured leader instances shall be explored to characterize leader potential for positions of greater responsibility derived from measures of performance.

PHASE II: Phase II will involve enhanced tool and measurement system development, evaluation, and validation.

Validation shall be done at various ranks and for various leader positions within the Army. The goal will be to achieve face, construct and predictive validity.

PHASE III DUAL USE COMMERCIALIZATION: Phase III will involve tailoring aspects of the measurement system to use in leadership domains beyond the US Army. Sister service and joint assignments would be prime candidates for immediate extension of the measurement system. Aspects of the framework will need to be tailored to make it applicable to organizations that hire for positions throughout levels.

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2) McCauley, C. D., Eastman, L. J., & Ohlott, P. J. (1995). Linking management selection and development through stretch assignments. Human Resource Management, 34, 93-115.
3) Mael, F. A. & Schwartz, A. C. (1991). Capturing temperament constructs with objective biodata. ARI Technical Report 939. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. ADA 245 119
4) Paulhus, D. L. (1986). Self-deception and impression management in test responses. In A. Angleiner & J.S. Wiggings (Eds.), Personality Assessment via Questionnaire (pp. 142-165). New York: Springer.
5) Objective Force Task Force (December 2002). Objective Force in 2015 White Paper.
6) Swets, J. (1964). Signal detection and recognition by human observers. New York: Wiley and Sons.
7) Weick, K. E. & Quinn, R. E. (1999). Organizational change and development. Annual Review of Psychology, 50, 361-386.
8) Weiss, D. J. & Shanteau, J. CWS: A User's Guide. http://www.ksu.edu/psych/cws/pdf/using_cws.pdf

KEYWORDS: Leadership, leader development, career, self-development, measurement, assessment

A03-024 TITLE: Semi-Automated Question Accumulation and Response System

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: TRADOC- Training Developments and Analysis Dir.

OBJECTIVE: To create and empirically validate a semi-automated system that uses desktop computer technology to answer questions posed on user specified topics. The system would allow subject matter experts (SME) without high-level computer skills to load topic-specific text information into the system and manage the system. An artificial intelligence component would allow the system to refine answers automatically based on SME input and questioner feedback.

DESCRIPTION: The Objective Force will be a networked system of systems with soldiers who update their knowledge and skills through reachback capabilities and life long learning. To fully meet the training needs of this networked force, a greater use of distributed learning and embedded training is required (TRADOC). SMEs and instructors spend a great deal of time responding to questions, many of which are redundant. A system that can appropriately answer questions would reduce the workload of SMEs and instructors, allowing them to spend more time on other crucial aspects of teaching and supporting life long learning. A successful system would also provide assistance to Objective Force soldiers when they have on-the-job questions that need immediate answers, are engaged in embedded training, or performing en route mission rehearsal.

While automated question answering systems have been developed previously, many have been an attempt to answer questions in far reaching content areas, like "Ask Jeeves". This process leads to vague answers and enormous databases that grow to an unmanageable size for a single administrator using a desktop computer. Question answering systems that cover limited content areas, like the Answer Wizard in Microsoft Help, have tended to be more successful in providing on-target responses, however these limited content systems lack administrator control and provide "canned" responses.

While the average computer user can ask questions of these systems, both types of systems require high-level technical skills to develop the content, maintain the knowledge-base, and manage the output. Presently, there is no automated question management system that runs on a standard PC administered by a person without high-level computer skills.

The proposed system would be a shell program with the capability of parsing information provided by an administrator to answer questions in natural language. For example, a SME could load text files that come from a particular book, topic notes, and other sources. The system would then use a combination of statistical (e.g., frequency of word usage, correlation of terms) and linguistic (e.g., latent semantic analysis, natural language processing, and knowledge-base) methods to locate information and generate appropriate responses to questions acquired from natural communication media (e.g., e-mail, text messaging, threaded discussions). In addition, based on input by the SME and answer feedback from the questioners, the system should refine successive responses. The SME would have control over the output of the system to determine that quality answers are generated, and as the system produced a higher percentage of quality answers the SME could allow the system to respond directly to the questioner. The SME would also have the ability to modify topic content. For example, a graphical file might be linked to a particular answer or set of terms, so that the graphics would be included in subsequent responses to related questions. In addition, the system should code the questions/answers in a common metadata format, so that they may be repurposed for use with a SCORM (Sharable Content Object Reference Model) compliant learning management system.

PHASE I: Phase I should determine the feasibility of producing a question answering system that runs on a desktop computer administered by a person without high-level technical skills. This feasibility study with specific recommendations for the system to be developed during the Phase II effort would be required by the end of Phase I.

PHASE II: In Phase II, the findings of Phase I should be used to develop a working version of the system to be assessed by instructors of distributed learning courses. The assessment should include courses in at least three different military content areas. The assessment of the system should cover the quality of responses, ease of use, and reactions from both students and administrators. The goal would be for the system to accurately respond to questions on topical information 95% of the time to the satisfaction of a SME.

PHASE III DUAL USE COMMERCIALIZATION: Ownership of a flexible, easy-to-use semi-automated question accumulation and response system should position the company well for integrating their system into distributed learning courses and learning management systems presently in use by both the private and public sectors. The system could be used in training and educational environments, as well as “help desks”.

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3) Martinovic, Miroslav (2002) Integrating statistical and linguistic approaches in building intelligent question answering systems. A presentation at the International Conference on Advances in Infrastructure for 3-busines, e-Education, e-Science, and e-Medicine on the Internet, SSGRR 2002W, in L’Auila, Italy. Available at www.ssgrr.it/en/ssgrr2002w/papers/81.pdf.
4). Moore, M. G. (2001) Surviving as a distance teacher. The American Journal of Distance Education, 15(2), 1-5.
5) TRADOC (2002) Military Operations: Force Operating Capabilities.
[Pamphlet 525-66] Fort M.

KEYWORDS: question, question answering, latent semantic analysis, natural language processing, artificial intelligence, language parsing, distributed learning, embedded training

A03-025 TITLE: Enhancing Warrior Ethos in Initial Entry Soldiers

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: US Army Infantry School, Dir. of Opns & Training

OBJECTIVE: Develop program to enhance the attributes of Warrior Ethos for initial entry soldiers.

DESCRIPTION: In his controversial, but widely quoted 1947 book, Men Against Fire, military historian S. L. A. Marshall wrote of tactical conditions faced by mid-twentieth century soldiers "at the opening of a new age in warfare when it appears certain that all operation will be accelerated greatly, that all ground formations must have greater dispersion for their own protection, and that therefore thought must be transmitted more swiftly and surely than ever. These things being true, it is an anachronism to place the emphasis in training and command primarily on weapons and ground rather than on the nature of man" (Marshall, 1966, p.39). Marshall wrote of individual courage: "…how to free the mind of man, how to enlarge his appreciation of his personal worth as a unit in battle, how to stimulate him to express his individual power within limits that are for the good of all" (Marshall, 1966, p. 23). The next paragraph, however, identified a problem: "we have never got down to an exact definition of what we are seeking" (ibid.).

More than 50 years later, this perceived shortfall is readily encompassed by what is defined as the Warrior Ethos. Field Manual 22-100, Army Leadership (DA, 1999) characterizes Warrior Ethos, the attitudes and beliefs of the American soldier, by "the refusal to accept failure" (p. 2-21). The total commitment exemplified by the Warrior Ethos lies in teamwork, discipline, and perseverance (Honore & Cerjan, 2002). Warrior Ethos is "developed and sustained through discipline, example, commitment to Army values, and pride in the Army's heritage" (DA, April, 2002, p. 16).

Marshall's prediction of the dispersed battlefield has come to fruition, as has an awareness of the human dimension of combat. The Objective Force soldier exemplifies "human characteristics such as common sense, battlefield instinct, and the warrior ethos [and] must react to issues of morality, and exercise mature judgment, while decisively wielding highly lethal weapons in the demanding, chaotic environment of war" (DA, 2002, p. 113). As the Objective Force exploits advances in information technology, the battlefield will grow more dispersed and the Warrior Ethos attributes even more important for leaders and soldiers. General Richard B. Myers, Chairman of the Joint Chiefs of Staff, defines the baseline attributes inherent in Warrior Ethos as cohesion, commitment, self-sacrifice, courage and leadership (Myers, 2002). The remaining issue is the feasibility of training and sustaining Warrior Ethos through providing an environment in which to nurture their development.

PHASE I: Phase I shall consist of a front-end analysis to determine the components of the constructs associated with Warrior Ethos, the fundamental attributes embodied therein and the environments suitable to enhance these values. Warrior Ethos encompasses Combat Arms, Combat Support and Combat Service Support operations; all areas shall be considered. Additionally, some feasible candidate training methods and environments shall be identified, including but not limited to the use of simulation and distributed training. Strengths and weaknesses of each environment shall be addressed. Example training vignettes and exercises exemplifying attributes of the Warrior Ethos for personnel of varied ranks and backgrounds shall be created, as well as proposed metrics by which progress can be measured. Solutions and examples may come from other than military archives.

Currently, training for initial entry soldiers provides a focus on the Army value system and the attributes of Warrior Ethos. The products of this research shall not duplicate the existing Army values training programs already in place in the various One Station Unit Training (OSUT) programs of instruction (POI) or in the training provided in the Basic Combat Training (BCT) POI but may expand upon them by providing a means of reinforcement for the training currently in place. Other on-going Warrior Ethos initiatives may be monitored but not duplicated.

Proposed solutions for development of a multi-faceted Warrior Ethos training program shall be documented in a Phase I report. The report shall include findings from the front-end analysis and examples of potential solutions for multi-echelon training in diverse environments.

PHASE II: In Phase II, training support packages, means of delivery, and assessment shall be developed and tailored for specific environments and echelons. An assessment plan shall be developed for review and approval. Performance measures appropriate for each environment (and specific cognitive attribute) shall also be developed, tested, and revised as necessary. An evaluation of the Warrior Ethos training package shall be conducted and documented in a report.

PHASE III: This phase includes tailoring the approaches and assessment procedures to other military and commercial markets. In addition to application throughout the Department of Defense, products from this research topic would have immediate benefit to personnel associated with the Department of Homeland Defense.

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2) Department of the Army, Army Leadership (Field Manual 22-100), Washington, DC, 1999.
3) Department of the Army, Military Operations: Force Operating Capabilities (TRADOC Pamphlet 525-66). Washington, DC, 2002.
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5) S. L. A. Marshall, Men Against Fire, Gloucester, MA: Peter Smith (1947); and New York: William Morrow & Company (1966).
6) Richard B. Myers, The Warrior Ethos, speech given to the Air Force Sergeants Association, Jacksonville, FL, 14 August, 2002.

KEYWORDS: Warrior Ethos

A03-026 TITLE: Ascertaining Bio-Mechanical Response of Armor Materials

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Soldier

OBJECTIVE: Design and development of an instrumented measurement device/fixture to measure the dynamic response of armor materials to non-penetrating ballistic impacts. This device will enable the assessment of non-lethal weapons effectiveness, and the potential for blunt force trauma injuries associated with personal body armor energy transfer characteristics when used as protection against otherwise lethal threats. The test device must be able to measure the ballistic energy that will be imparted to the human thorax, and must measure the time-and space-resolved loading and deformation of the armor material, including rate effects, associated with the energy and momentum transfer due to non-penetrating impact by military anti-personnel (lethal and non-lethal), and small caliber armor piercing ammunition. Data obtained using this device will be used to assess and compare new armor materials, and as input to biomedical models of behind armor injury currently in development to assess and model blunt force trauma, incapacitation and survivability criteria for personnel.

DESCRIPTION: Researchers and developers of personal body armor systems have a need for reliable experimental techniques for assessing the relative effectiveness of body armor materials in preventing injury related to impact loading imparted by stopping small arms projectiles. Likewise, developers of anti-personnel ammunition, both lethal and non-lethal, require quantitative measures of weapons effectiveness for enemy incapacitation. Impact induced loading occurs through the transfer of energy and momentum from the projectile, through the armor materials and any equipment and clothing external to the armor, to the human wearer. The initial deformation of the armor materials is caused by the propagation of impact induced stress waves and their interactions, and the subsequent deformation of the materials occurs through sustained stress imposed on the armor after the wave interaction effects are completed. The initial deformation of the material and associated energy and momentum causes changes in the material to take place during the first few microseconds after the impact. This leads to changes in the initial mechanical properties of the material, which may influence the material response to the sustained stresses. The goal of this effort is to provide increased understanding of how various armor system components and combinations may mitigate the energy imparted to the human thorax associated with ballistic impact, and to help identify design parameters for enhanced non-lethal weapons. It has been pointed out that body armor material developers lack valid testing methods to determine if the body armor they develop will prevent life-threatening blunt trauma injuries. As a consequence, future body armor systems may protect soldiers from penetrating injuries, yet allow serious or lethal blunt trauma injuries.

This need has grown from the military's desire to develop and evaluate user-friendly defeat mechanisms and material systems for small arms protection and other urban environment threats at reduced weights and enhanced protection. Research in this area has been limited to date due to ballistic range instrumentation limitations. The major goal of this effort will be to determine methods to measure and characterize the transfer of energy to the body during the ballistic impact (blunt trauma). A successful program will generate experimental data that can be compared to the energetic parameters being used to develop injury models, and to directly support the various modeling efforts in this area. By measuring how much energy is transferred, how fast is it transferred, how deeply the body is penetrated and how large an area/volume of the body is affected, researchers will be able to assist military users with defining what areas of the body are most desirable to protect, and to what level of protection. The experimental evaluation of the designed test fixture will include: temperature conditioning, ability to withstand non-penetrating ballistic impact from fragmenting munitions (2 grain small fragment simulators up to 207 grain large fragment simulators), small arms projectiles (.22 cal to at least .30 cal), non-lethal weapons (e.g., 'bean bag"), and could include thrust/stab resistant materials testing.

PHASE I: Establish the feasibility of developing a Test Device which can be used to measure dynamic material response during a non-penetrating ballistic impact and demonstrate that the device can used to measure momentum and energy loading characteristics critical to supporting human thorax blunt trauma effects from the ballistic threats listed in the description.

PHASE II: Fabricate an Armor Materials Dynamic Measurement Device to Assess Blunt Trauma Effects.

PHASE III DUAL-USE APPLICATIONS: Potential exists for supplementing National Institute of Justice prescribed test fixtures, and use in development of commercial ballistic personal protective systems, as well as military body armor systems.

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KEYWORDS: Ballistics, Body Armor, Dynamic Material Response, Material Deformation, Test Fixture, Blunt Trauma

A03-027 TITLE: <u>Actively Controlled Rotary Actuator For Vehicle Suspensions</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Active suspension systems extensively utilize linear struts to control a vehicle's suspension. These struts are passive, semi-active and fully active systems. The semi-active and fully active systems integrate actuation functions with their spring and damping capability. The linear struts are not optimally suited for all applications due to packaging and performance limitations (length of stroke, response time and dynamic control of stiffness and dampening). Suspension systems for future vehicles, such as swing arm or multi-jointed leg systems, would greatly benefit from compact actively controlled rotary actuators instead of the traditional linear strut.

The objective of this topic is to develop an actively controlled rotary actuator applicable to single or multi-element swing-arm automotive suspension systems. This actuator when integrated with such a suspension system must be more compact, consume less power to operate and result in lower absorbed power to vehicle occupants when the vehicle is operated across rough terrain, than linear actuator systems. It is anticipated that the development of such an actuator will be a major departure from conventional approaches. In particular alternative approaches to the traditional functionality of a spring and dampening system are sought. It is assumed that electric powered vehicles will be the future norm so utilizing electrically powered systems is acceptable as an alternative to hydraulic or pneumatic systems.

DESCRIPTION: The proposal shall include a rotary actuator concept and estimates of capabilities and performance in sufficient technical detail such that the Government fully understand its operation and can arrive at the same conclusions claimed by the offeror. To facilitate sizing the actuator the offeror shall assume the actuator is for a four-wheel hybrid electric drive vehicle with common swing-arm suspensions at all wheel positions. In-the-wheel electric motors provide propulsion. The actuator shall be integrated into either a single or multi-element swing-arm suspension. The vehicle's weight is 1000 lbs per wheel. Performance estimates shall be made based on a 2 in. RMS course consisting of 8 in. radius half round bumps with a vehicle speed of 50 mph. The offeror shall also show the applicability of the actuator to facilitate vehicle climbing up, down and across complex terrain such as building rubble or other obstacles a soldier might experience. An estimate of the power consumption for operation shall be provided.

PHASE I: The Phase I effort consists of developing a detail preliminary design of the actuator that also shows how it is integrated into the aforementioned swing-arm suspension. Detail performance and energy consumption calculations shall be made.

PHASE II: The Phase II effort shall consist of developing a detail design, fabricating and testing the actuator subject to realistic operational conditions.

PHASE III DUAL USE APPLICATIONS: The actuators can be used on military vehicles and by the automobile industry especially on trucks and SUVs

REFERENCES:
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KEYWORDS: Mobility, suspension, rotary actuator, electric drive, swing arm suspension

A03-028 TITLE: Hydrogen Generation and Storage for Fuel Cell Systems

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To develop new/improved methods for hydrocarbon fuel processing and hydrogen storage for use with hydrogen/proton exchange membrane (PEM) or solid oxide fuel cell systems.

DESCRIPTION: Small and efficient hydrogen/PEM or solid oxide fuel cell systems are in development to meet the need for power for vehicle-borne battery chargers, vehicle silent watch and field headquarters. The power range of interest is approximately 500 to 2000 Watts. The main difficulty that remains to be overcome for such applications is the development of compact fuel reformers that produce hydrogen gas on demand. Very often, the purity of reformate is also an issue. Also, a means for safe and efficient storage of pure hydrogen for the lower power levels needed for the dismounted soldier is of interest.

For hydrogen generation, we are seeking new catalysts and improved reactor design for the reformation of readily-available hydrocarbon (and especially diesel-) fuels and the identification of other chemical reactions and processes that will allow a safe, well-regulated production of gas at a high weight percentage relative to the weight of fuel plus container.

For hydrogen purification, we are seeking new materials and methods to remove carbon monoxide and/or sulfur compounds from the reformate gas. The proposed technologies may include, but not be limited to, Pd-based membrane assemblies and post-reformation sulfur scrubber/adsorbent. For hydrogen storage, we are seeking new materials that will reversibly adsorb hydrogen to an extent greater than 3% by weight.

PHASE I: Phase I will identify materials, processes and conditions that could result in the required hydrogen generation, purification or storage components. Initial experimentation to prepare required new materials or to devise new processes will be conducted.

PHASE II: Phase II will include the preparation of new materials, optimization of chemical processes and the demonstration of a breadboard prototype fuel processing components, sub-components or hydrogen storage units for 0.1 – 2 kW fuel cell systems.

PHASE III DUAL USE APPLICATIONS: The power and energy generation components under consideration here are of great potential value for uses as small home electrical generators, and power for a variety of portable civilian electronic and electrical equipments.

REFERENCES:
1) International J. OF Hydrogen Energy 26 (3): 243-264 MAR 2001.
2) J. Power Sources ( 106) p. 231, 2002.

KEYWORDS: Hydrogen, fuel reformer, hydrogen generator, hydrogen purification, fuel processor, APU.

A03-029 TITLE: Innovative Methods for Geolocation and Communication with Ultra-Wideband Mobile Radio Networks

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To develop signal processing algorithms and architectures to facilitate geolocation and communications using ultra-wideband radios.

DESCRIPTION: Ultra-wideband (UWB) radio networks have the potential to provide very high bandwidth mobile wireless communications in Army tactical scenarios, including challenging urban (indoor/outdoor) environments [1-3]. The high bandwidth implies significant potential for high resolution positioning systems, as well as wall-penetrating radar and other applications. This geolocation capability with a handheld device would find applications in areas where GPS may fail (indoors, challenging urban environments such as those envisaged in MOUT, special forces requirements, etc). Many issues surround implementation, including propagation characteristics, optimal receivers, modulation formats and coding, interference rejection, channel estimation and equalization, spatial processing, and others [4]. Optimal signal design and evaluation of performance bounds are important. Acquisition and synchronization issues are significant challenges in receiver processing. The ability to combine various signal processing methodologies into a low power implementation is critical to enable use of UWB for geolocation and communications. New network protocols may be necessary for self-configurable mobile networks. The goal of this SBIR is to develop processing algorithms and architectures that exploit innovative techniques to overcome these hurdles.

A successful technique should provide the user with a robust real-time method for communicating a desired digital signal over a potentially time-varying dispersive channel, in the presence of undesired interference, leading to high-resolution position estimation. Geolocation algorithms should be robust. Temporal, spatial or other forms of diversity are very likely to be required to achieve this goal.

PHASE I: Propose, analyze, and simulate novel techniques for geolocation using UWB radio networks; compare with existing techniques; analyze computational requirements and complexity; suggest designs for real-time implementation.

PHASE II: Develop working prototype radios and demonstrate in a real-time experiment; market the processor to the telecommunications industry.

PHASE III DUAL USE APPLICATIONS: As wireless communications systems move to higher and higher data rates, advantages of conventional methods become less and less due to the increase in receiver complexity for equalization and other tasks, and proliferation of in-band interference. In addition, very fast A/D converters are significant power consumers. Thus, UWB systems may be required to gain advantages of spread spectrum systems, while at the same time minimizing multi-user access interference and ameliorating the multipath problem. Mobile network protocols that are self-configuring and robust are called for in a variety of commercial situations, and represent a significant hurdle for current commercial wireless systems. E-911 requirements are being written into commercial wireless phone standards; however, conventional designs are likely to fail in challenging scenarios, such as indoors, severe urban canyon environments etc. Therefore, successful new methodologies for UWB radio networks will have significant commercial potential for high bandwidth multi-user systems as well as for precise positioning.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Successful development of low complexity ultra-wideband systems may provide a cheaper alternative to expensive, high complexity, very wide bandwidth conventional communications and positioning technologies.

REFERENCES:

1) Workshop on UWB, sponsored by the Army Research Office and the University of Southern California, May 25-28, 1998, Solvang, California.
2) 1999 Ultra-Wideband Conference, Sept. 28-30, 1999, Washington, DC.
3) 1999 IEEE Military Communications Conference (MILCOM-99), special session on Ultra-Wideband Communications, Oct. 31 - Nov. 3, Atlantic City, NJ.
4) A. Swami and B. M. Sadler, "Issues in Military Communications," IEEE Signal Processing Magazine, Vol. 16, No. 2, pp 31--33, 1999.
5) 2002 IEEE Conference on Ultrawideband systems and technologies, 21-23 May 2002, Baltimore, MD.

KEYWORDS: Wireless communications, ultra-wideband, geolocation, diversity combining, equalization, mobile networks.

A03-030 TITLE: Wideband High Fidelity I-Band Digital Radio Frequency Memory (DRFM)

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Research and develop a Wideband High Fidelity I-Band Digital Radio Frequency Memory (DRFM) suitable for airborne generation of multiple high fidelity simulated targets for long-range radar sensors.

DESCRIPTION: Current DRFM systems fall short in supporting future airborne target simulator applications for long-range radars that require high fidelity generation of multiple simultaneously delayed replicas of arbitrarily complex radar waveforms with very large instantaneous bandwidths. The proposed DRFM in the envisioned airborne target simulator application would be an extensible system with multiple output signal channels, each having an independently programmable dynamic time delay and doppler frequency offset. The basic DRFM proposed should have at least 4 channels and be expandable to a total of at least 16 channels.

Ideally, the proposed DRFM would handle radar signals with instantaneous bandwidths of 2 GHz or greater anywhere in the range of 8.0 to 11.0 GHz. Proposed DRFM designs with instantaneous operating bandwidths of less than 2 GHz will be considered, however, anything less than 1 GHz will not be considered. The operating frequency band would be set programmatically by the user to position the instantaneous bandwidth anywhere in the range of 8.0 to 11.0 GHz.

The signal delay for each channel in the proposed DRFM should be user programmable over a range of 500 nanoseconds to 30 milliseconds in 2 nanosecond steps. System proposals with wider delay ranges and/or smaller step sizes for each signal channel will be given extra consideration. The proposed DRFM design should allow the programmable delay for each channel to be updated at a rate of at least 25 kHz.

Signal fidelity and spurious signal levels are major concerns in the design of the proposed DRFM. Ideally, the delayed replicas of the radar waveform reproduced by the DRFM should be indistinguishable from a real radar target return signal. This level of fidelity will require spurious signal levels (including harmonics) below -40 dBc or better inside and outside of the DRFM operating band. The proposed DRFM should be capable of handling peak input power levels ranging from -10 to -50 dBm while maintaining this level of signal fidelity and spurious signal performance. DRFM designs offering high signal fidelity, low spurious signal levels and superior phase noise performance will be receive preference over less capable designs. Signal output levels on each channel should be suppressed when no input signal is present to prevent spurious exitation of radars under test. The proposed DRFM should include protective circuitry to prevent system damage for input signal levels of +10 dBm or more.

The maximum output power level for each channel of the proposed DRFM should be at least +23 dBm. Each channel should incorporate output power attenuation that is user programmable over a range of 0 to 80 dB in steps of 0.1 dB or smaller. This attenuation capability is required to implement dynamic adjustment of target amplitude as a function of range. The proposed DRFM design should include provisions to maintain a flat frequency response characteristic for each output signal channel over any operating frequency band selected by the user, over any arbitrary input signal level and output power attenuation, and over an operating temperature range of 0 to +55 C. The desired level of flatness is +/- 1 dB. DRFM proposals will be given extra consideration to the degree that they effectively address this performance issue. The proposed DRFM should incorporate a doppler frequency offset for each output signal channel that is user programmable over the range of +/- 2 MHz with a resolution of 0.1 Hz or better.

The proposed DRFM envisioned would incorporate an Ethernet 10/100BT interface employing a TCP/IP protocol for all user programming of the DRFM. User commands should be designed and structured to minimize system response time to user commands, provide both low-level and high-level control of all DRFM functions required for radar target simulation, implement initialization to a known state, and provide built-in-test (BIT) information to assure proper system operation and identify the source of any major component malfunctions. DRFM design proposals will be given extra consideration if they provide additional logic signal outputs to facilitate integration of the DRFM with Global Positioning System (GPS) time code equipment. Additional logic signal outputs desired include an "Input Signal Present" line providing a positive true TTL level indicating the presence of a DRFM input signal, and a "Delay Update" line for each output signal channel, providing a positive true TTL pulse coincident with the internal DRFM execution of each delay update event on a particular output signal channel.

The proposed DRFM system should be mountable in a standard half-height rack and operate without degradation in a field van or on a subsonic fixed or rotary wing aircraft at up to 15,000 feet above mean sea level over an ambient temperature range of 0 to +55 C. Microwave signal input and output ports should utilize APC3.5 female connectors and have characteristic impedances of 50 ohms with Voltage Standing Wave Ratios (VSWRs) of less than 2:1. Prime power available to operate the proposed DRFM is 115 VAC, 60 Hz. DRFM design proposals will be evaluated on the basis of their responsiveness to the design goals above and the feasibility of the proposed design.

PHASE I: Research, develop and propose a prototype 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 DRFM system prototype proposed in Phase I. Characterize and refine the system performance in accordance with the goals stated in the description above. Document the DRFM system theory of operation, design, component specifications, system performance and any recommendations for future enhancements.

PHASE III DUAL USE APPLICATIONS: The proposed research and development (R&D) effort has wide commercial application to microwave signal processing functions in military and commercial radar sensors and communication systems. This R&D effort will yield advancements in ultra high speed (above 2 GHz) analog/digital system design involving Analog-to-Digital Converters (ADCs), Digital-to-Analog Converters (DACs), multiplexers and demultiplexers, and memory components. These advancements will have direct application to the design of a wide variety of systems employed in both military and commercial applications.

Military applications of the proposed wideband DRFM development include radar target simulation and electronic countermeasures signal generation. Airborne generation of simulated radar targets utilizing the wideband DRFM technology developed in this effort could exercise air and missile defense system sensors with fewer air breathing and missile target vehicles, resulting in hundreds of millions of dollars in cost savings while providing increased opportunities for exercising these system sensors.

In addition to providing DRFM technology suitable for testing next generation radar systems, commercial applications of the proposed R&D effort include arbitrary waveform generators and signal processors, vector signal generators and modulators, telecommunication circuit emulation and test equipment, voice and data packet switching and routing equipment, and other systems employing ultra high speed signal conversion, processing, switching, routing and storage functions.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Cost savings exceeding 127 million dollars has been demonstrated using DRFM-based radar target simulators instead of live targets on SHORAD radar test programs. Development of the proposed system will be instrumental in extending these cost savings to other air and missile defense systems.

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1) "Electronic Warfare Vulnerability Assessment of Radar Systems," http://www.arl.army.mil/slad/Services/Mkt33.html
2) Pace, Phillip E., "Advanced Techniques for Digital Receivers," (Artech House Radar Library), ISBN: 1580530532, July 2000.
3) Schleher, D. Curtis, "Electronic Warfare In the Information Age," Artech House, ISBN: 0890065268, July 1999.

KEYWORDS: microwave, sensor, radar, target simulator, target simulation, DRFM, delay, digital, memory

A03-031 TITLE: <u>Advancing the Objective Force Through Mulitnational Coalitions and Interagency Task Forces</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: USAREUR

OBJECTIVE: To provide a model of multinational teamwork and develop methods and information systems to promote rapid formation of multinational and interagency teams to combat terrorism through decisive warfighting and support and stability operations (SASO).

DESCRIPTION: Multinational operations are a critical component of current U.S. Army deployments. Recent examples include Somalia, Haiti, Bosnia-Herzegovina (BiH), Kosovo, and the Philippines. Multinational operations require Army commanders and staffs to work closely with NATO forces, the international community, and non-governmental organizations. Since the terrorist attack on America the Army increasingly participates as members of joint and interagency task forces with team members from across DoD, the FBI, and the CIA. Whether it is to combat terrorism or keep the peace and provide disaster relief, rapidly forming and maintaining multifunctional teams to conduct tactical, operational, and strategic missions will continue to be a core Army requirement. Future operational challenges include increasingly joint, multinational, and interagency coalitions during the stability phases of operations. In the future operational environment, Objective Force leaders and soldiers must be able to transition smoothly from warfighting to peacekeeping to maintain a strong power base.

Little is known about how to rapidly form and support multinational and interagency teams for military operations. Research and development has primarily focused on the priority mission of the U.S. Army--fighting and winning the nation's wars. It has been implicitly assumed that an army prepared to fight can adapt their warfighting skills and information systems for full spectrum operations. However, in an initial investigation, U.S. Army unit personnel reported that their pre-deployment training had not fully prepared them for support and stability operations (Klein & Pierce, 2001; Pierce & Klein, 2002; Pierce & Pomranky, 2001). Barriers to learning and performance included the Army's approach to deployment training (Ross, 2000; Ross & Pierce, 2000; Ross, Pierce, & Baehr, 1999), organizational design of the multinational, military headquarters, and command and control systems available for peacekeeping. A high unit operational tempo, personnel rotation cycles that had key unit leaders and staff members rotating into and out of the unit less than 30 days before deployment, and a lack of training environments to practice support and stability operations hindered their preparation. Further, training did not include meaningful or accurate representation of the role of multinational forces, the international community, or non-governmental organizations. A lack of skill in multinational teamwork was specifically identified as a weakness. Organizational barriers included a lack of information system interoperability and restrictions on information access among team members. Communication barriers included lack of language skills or the means to interpret non-English words. Finally, command and control systems designed for warfighting were not optimal for maintaining situation awareness required for making decisions in support and stability operations.

Phase I: Phase I will define Objective Force requirements to work within multinational coalitions at the Unit of Employment (UE) and Unit of Action (UA) levels. Team models and theories to identify team process or organizational barriers unique to a military system of systems will highlight the impact of several possible variables on team performance. These variables may include, but are not limited to, the presence of a military culture that transcends national cultural boundaries, organizational issues that arise from distributed teams and collaborative information technology, and cognitive differences in teamwork that can be attributed to culture. Phase I research should also address information system design requirements suitable for decentralized, distributed, and highly mobile team operations in complex and dynamic situations.

Current observations of multinational teamwork at the sustainment force headquarters in Sarajevo, Bosnia-Herzegovina and theoretical research is available to inform each of the team and organizational areas identified. However, a need exists to systematically apply the theoretical literature to the Army to better understand team, organization, and information system requirements for joint, multinational, and interagency military operations (Salas, Dickinson, Converse, & Tannenbaum, 1992). The application of this literature should result in a better understanding of military team performance requirements in multinational coalitions and interagency task forces and identify ways to facilitate team development through training, organizational design, and technology. The feasibility study shall also determine the usability of current team models and theories to the formation and support of military teams, develop a taxonomy of military team requirements for full spectrum operations, and identify knowledge gaps.

PHASE II: Phase II would build on the theoretical understanding from Phase I to develop prototype training programs to prepare the Army to participate as members of multifunctional, non-hierarchical teams. Training programs must leverage advances in simulation technology to create synthetic task environments that allow practice of complex cognitive tasks and promote development of adaptable leaders and teams. Synthetic task environments shall be designed to clearly link objectives to performance measures to support adaptive learning (Ross, Pierce, & Baehr, 1999). Training programs must be designed to meet the needs of the Army, in that they must be low cost, easily modifiable, and usable with co-located or distributed teams. Training programs would also define organizational processes required for rapid development and maintenance of high performing teams. Further, and as part of the training program, Phase II would require the introduction, assessment, and iterative development of information systems that support collaboration among diverse team members performing full spectrum military warfighting and peacekeeping operations. Products would include collaborative work tools as well as refined requirements. A possible solution to communication barriers might be rapid language translation within specific domains. Finally, Phase II will require a model for moving legacy Army systems to the Future Combat System concept of a multinational coalition strategy that is based on a system of systems architecture and incorporates information technology interoperability among U.S. forces and coalition partner. This model should be sufficiently detailed to allow Depart of Army and/or Joint Forces Command analysts to perform experimentation with proposed concepts.

PHASE III DUAL USE COMMERCIALIZATION: Models, methods, and tools to promote development and maintenance of multinational and interagency teams for military operations will advance the state of the art in international cooperation regardless of mission (Klein, Klein, & Mumaw, 2001). They will be integrated into the Army's All Source Analysis System (ASAS), the Future Combat System (FCS), and operational systems of the Department of Homeland Security to enable teams of intelligence specialists to collaborate and assess emerging complex situations.

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KEYWORDS: Team Performance, Organizational Design, Culture, Cognition, Multinational Operations

A03-032 TITLE: Crew Survivability Inside Future Combat Systems (FCS) -Type Vehicle: Techniques for Ammunition Protection from Fragments, Shock, and Fire

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: IAV & FCS programs manaement are being approached

OBJECTIVE: To research, study and propose devices, methods and designs to reduce the chances of inside vehicle munitions detonation and explosion, for crew survivability inside this class of vehicles. Creative and innovative techniques and devices are sought to make the inside vehicle crew survive a hit from a small arms (12.5mm) and medium caliber (20, 25, 30 mm) when the inside munition is hit by the spall resulting from the armor perforation.

In addition, these
munitions should also be protected from excessive heat resulting from fires inside the vehicle The designs and methods need to be modular, i.e., not vehicle specific, and may also consider round to round protection (jackets) as possible munition factory-installed feature. Light-weight, low-cost, simple, practical, human-factors friendly, effective methods and devices, in a tight crew space inside the vehicle, are desired. Two different, viable methods/devices/designs are be submitted as the outcome of a study of different approaches conducted in this study. Those designs have to be shown to be guided and soundly supported by the analyses performed.

DESCRIPTION: Several methods/devices/designs that can protect the inside-the-vehicle large-caliber munition (105-mm caliber diameter, as a representative case) stewed in their munitions rack inside an IAV- or FCS-Type vehicle, are to be innovated, researched and studied to recommend the best two designs/devices. The three mechanisms of burning, detonation, and the explosion of the propelling charges inside their steel/brass/aluminum/combustible-case of the representative caliber of 105mm, should be considered. The propellant mass in the
representative case is about 10 kg of charges. The typical shapes of propellant charges are long sticks and short cylindrical granular, among others. The vehicle's wall may be considered made of hard steel and of about 15-mm thickness. The munition case wall may vary in thickness from 2 to 8 mm. Protection methods are sought to prevent ammo detonation or explosion under the two threat scenarios below:

1- From behind-armor-debris and fragments resulting from a representative threat, say from the 30mm munitions. The representative debris fragment may be modeled as of about 5-gm in mass, 10-mm in maximum diameter and of velocity of about 800 m/s. Several angles of impact with the munitions rack may be considered. Few munition-case thickness and case material may be considered.

2- Protection from flash and sustained fire temperatures. Flash fire may be considered of temperature of 1700 F for ten seconds, and the sustained fire is of 400 F for two minutes.

For feasibility study considerations, the munitions rack may be modeled as a box of dimensions of, say, 1.0-m long, 0.6-m wide and 0.45-m high. The designs should not interfere with the unhindered use of the rack by the loader/gunner.

PHASE I: To provide concepts, perform studies, analyses, computer simulations for several protection methods/devices/designs, with currently available material, that are suggested to protect the stewed munition (mainly the propellant charge inside the ammo casing) from detonation, explosion, or burning. At least two designs of protective methods and designs are to be submitted with their attributes of weight, shape, and their other physical properties and their predicted performance results. All assumptions and properties used need to be stated and justified.

PHASE II: To produce, deliver and test prototypes of the two best protective methods/devices selected. Testing may initiate on possibly a smaller scale model and then proceed to a full scale testing with live munition in static testing. Necessary changes and improvements may be performed based on the performed tests. Weight, cost estimates per copy with considerations for mass production shall be given.

PHASE III: Perform design changes for adaptation to the mass production for retrofitting the particular vehicle model selected by the Army for installation. Adapt or modify the design provided to the Army, to suit civilian use as for civilian munition transportation trucks which cross the US continent every day, and may be subject to the new international terrorism attacks and ambushes using RPG-type weapon. Consider alteration for other civilian use in protection under high speed, but non-ballistic impacts. Consider variation in methods to enclose and protect both small (like the 2.75-inch rockets) as well as large missiles either bare under aircrafts or in their launch tubes on board navy ships, or inside their pods on Army/ Marine helicopters. Also protective shields for mine clearing personnel who are subjected to possible premature detonations. Civilian applications include jet engine interior protective shield on civilian airliners (against the separation of fast rotating turbine blade pieces) for vital engine parts. Also, in providing shields between machine operators and their machinery which produces unexpected small chips at high speed that resembles bomb fragments. The thermal protection aspect can be used for protection of fuel tanks in military as well as civilian vehicles.

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limited distribution. However, the following references are provided for general information and as background material.

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KEYWORDS: IAV vehicle, FCS vehicle, crew survivability, injury, ammunition protection, explosion, schock,fragments, heat

A03-033 TITLE: Novel Hierarchical Hybrids for Transparent Armor

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Soldier

OBJECTIVE: Design, develop and optimize hybrid hard/ductile composites through exploiting emerging nano-materials technology to impart multi-functionalities as well as enhance ballistic performance for transparent ballistic shields Armor.

DESCRIPTION: Incorporation of nanomaterial additives to polymers and other structures is an area of intense interest to the Army for the design of next generation transparent lightweight armor with enhanced survivability against emerging threats. The reduction of materiel weight of new armor systems can be realized through hybridization with proper morphological control of material hierarchy. These include system integration and optimization of existing transparent polymeric materials, development of new, higher performance ultra-lightweight nano-composite materials, as well as incorporation and integration of multiple functionality into the hybrid systems. The role of mesophase structures on the overall physical and mechanical properties needs to be determined. Interphase between the nanofiller and host polymer matrix is critical, therefore, interphase optimization with proper surface chemistry needs to be demonstrated to ensure the desired mesophase strength. The goal of this effort is to demonstrate Materials-By-Design strategy for the development of transparent shields with enhanced ballistic performance for personnel protection as well as with EMI shielding capability for vision blocks for ground vehicle protection.

PHASE I: Demonstrate feasibility of exploiting emerging nano-materials technology and identify nano-fillers, material components, advanced synthetic routes, compounding processes, and fabrication methods for incorporating into polymer matrix systems. Quantify the effect of nano-materials on the overall durability of the hybrid composites and demonstrate the success of overall ballistic performance against the high velocity 9mm hand gun threats. Identify the pathway for providing enhanced EMI shielding capability without degrading other desired physical properties and mechanical integrity. Provide candidate hybrid composites for the Army for property validation.

PHASE II: (a) Scale up fabrication and assemble process for producing prototype of at least 12" x 12" in size. (b) Modify as required and quantify ballistic impact performance with respect to the areal density of the nanocomposites. (c) Integrate the EMI shielding capability into the optimized hybrid nanocomposite structures.

PHASE III: Potential dual use applications include vision blocks for helicopters and aircrafts, armored cars for counter-terrorism protection, VIP vehicle protection, and Government buildings.

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KEYWORDS: nanomaterials; hierarchical hybrids; multi-functionalities; EMI shielding; transparent armor; ballistic performance.

A03-034 TITLE: Non-Imaging Disposable Sensor System

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a complete sensor system that includes several disposable sensor nodes that communicate with a hand-held display. Each disposable node should include one (or more) transducer(s) with suitable amplifier/filter(s), a signal processor, and a communication device, all in a single package for under $10 (projected unit price, quantities of 1-10 million/year). These sensor nodes should be extremely small (1-10 cm^3), lightweight (1-30 gm), and consume extremely low amounts of power (0.1-1 mW). It is anticipated that such sensors could be used by individual soldiers for surveillance and/or self-protection, by small groups of soldiers operating in an urban environment, and/or as "feelers" in a large sensor network.

DESCRIPTION: The specific sensor modalities are not specified in this topic, but could include acoustic, seismic, magnetic, E-field, non-imaging passive infrared (PIR), passive RF, chem/bio, and/or any other transducer(s) that could be used to detect any targets or threats of military significance, and that could be built at a unit production cost that is on the order of $1/transducer. Individual sensors could be multi-modal, and/or a mix of individual sensors with different modalities could be used to detect a wide range of targets and/or threats on the battlefield, including: personnel (armed, unarmed); ground vehicles (wheeled, tracked); aircraft, including unattended arial vehicles (UAVs) and micro-air vehicles (MAVs); explosions, including gunfire, artillery, and rocket launches; chemical and/or biological threats, and/or monitoring of power lines, local communications, etc.

Performance goals for individual disposable nodes are secondary to the size, power, weight, and cost objectives listed above. Examples of desired performance include the following: one month continuous operation using internal batteries and/or energy harvesting, low false-alarm rate (Pfa < 1 false alarm/hour in quiet military training environments, and Pfa < 3 false alarms/hour during normal military training operations), detection of personnel (Pd >0.9 @ 2 m, >0.7 @ 5 m, >0.3 @ 10 m, <0.01 @ >50 m), classification of soldiers (Pc > 0.5 @ 2 m), detection of large vehicles (Pd >0.9 @ 20 m, >0.7 @ 50 m, >0.3 @ 100 m, <0.01 @ >500 m), classification of wheeled/tracked/airborne vehicles (Pc > 0.5 @ 20 m). Other desirable performance goals include detection and/or classification of other targets and/or threats, including: unattended air vehicles (UAVs), micro-air vehicles (MAVs), and other robotic or autonomous vehicles; gunshots, mortar/artillery/rocket launches, and/or explosions; power line activity, telephone activity (wired, cell phone, satellite phone, tactical radio, etc.); chemical and/or biological threats; node tampering, etc. Target and/or threat reports should be on the order of 100 bits long (excluding communications overhead), and should include a timestamp, sensor node ID, target/threat detection/classification code; it is desirable to also include a confidence level estimate.

The type of signal processor is also not specified in this topic, but must consume exceptionally low amounts of power (e.g., 100 uW average). This may be achieved through a combination of power-efficient processor design, low clock rate or asynchronous computing, efficient algorithm(s), and/or low duty cycle(s). The processor output should include a sensor ID, timestamp, target type (simple classification), and confidence level. To process disparate signals from an extremely wide range of sources, multi-modal, or "orthogonal" sensor fusion is anticipated at some level. If possible, the processor/algorithm should be adaptable (to environment) and/or programmable (for a particular mission).

The communications mode is not specified, although very low bit rates (<1 bps average), duty cycles (<1%), and ranges (<100 m ground-to-ground, <1000 m ground-to-air) are anticipated. The communications source may be acoustic/ultrasonic, RF, or IR, or it may resonate or reflect "on command" from an external receiver. One-way communication is presumed to exfiltrate data to end-users and/or more capable sensors, gateways, etc.

Knowledge of the sensor location and/or orientation is often necessary; however, this topic does NOT address this issue. Under this topic, it can be assumed that such knowledge is available or can otherwise be determined during emplacement of the low-cost sensors. This topic also does NOT address issues related to information assurance (i.e., encryption, authentication, non-repudiation, etc.). It may be desirable to assimilate reports from multiple sensors over time, correlate this target and/or threat information with topographic and/or tactical features, and build one or more user interface(s) that provide(s) real-time situational awareness to individual soldiers and/or other C4I (command, control, computers, communications, and intelligence) assets; however, this topic does NOT address issues related to network-level information fusion, communications, and/or displays.

PHASE I: Develop an overall system design that includes specification of low-cost, low-power sensors (modalities, transducers, amplifiers, filters), signal processors (sampling issues, processing mode(s), sensor fusion), and communications (type, duty cycle). Particular attention should be placed on unit production cost; other important issues include: power and energy consumption; size and weight; and robust operation (detection of a wide variety of targets under a wide variety of operating conditions).

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions. The "system" should include at least 10-20 low-cost, low-power sensor/processor/transmitter nodes, and at least one hand-held interrogator/receiver/display unit.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications where automatic surveillance and tracking are necessary – for example, in overseas peacekeeping operations or in enhancing security in industrial facilities.

REFERENCES:
1) Larry B. Stotts, "Unattended ground sensor related technologies; an Army perspective", Proceedings of SPIE, Vol. 4040, pp. 2-10, April, 2000.
2) John Eicke, "Disposable sensors: a vision of the world ahead", Proceedings of SPIE, Vol. 5090, April, 2003.

KEYWORDS: disposable sensors, non-imaging sensors, tripwire sensors, low-cost, low-power, multi-modal, sensor fusion

A03-035 TITLE: <u>Cross-Layer Designs for Energy-Efficient Sensor Networking</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Intell., EW and Sensors; Command, Cntrl., and Comm

OBJECTIVE: To develop cross-layer approaches to radio design for energy-efficient ad hoc sensor networking.

DESCRIPTION: Traditional designs of random access protocols and the physical layer radio have been separate, with each viewing the other component as a black box. Advances in signal processing at the physical layer dictate that the medium access control (MAC) layer take these advances into account. Benefits of a cross-layer design are evident in some recent designs such as the 802.11 standard. The Army vision for Future Combat Systems (FCS) envisages the deployment of large scale sensor networks to provide timely and reliable information to the soldier.

Designing peer-to-peer communication systems for these radios faces several challenges such as mobility, uncertain terrain/channel conditions, scalability issues, and severe constraints on bandwidth and energy. The communication link will be asymmetric, and the users will be asynchronous, the sensors may be duty-cycled, and the load on the network may vary from quiescent to heavy loads. Thus the traditional single TDMA or CSMA/CA protocol, and the traditional barriers leading to separate design of networking, medium access and physical layer functions will not be adequate.

A successful cross-layer design should lead to a robust low-complexity radio transceiver that can cope with potentially time- and frequency-selective channels, undesired interference, as well as thermal noise. The cross-layer design should be amenable to implementation and should be robust to reasonable variations in the environment (channel, users, interferers, etc.). The protocols should be energy-efficient and scalable.

PHASE I: Propose, and analyze, novel cross-layer design techniques leading to robust scalable architectures for sensor networks, operating under varying system loads. Analyze the computation and implementation complexity of the joint design vs. traditional separate designs. Conduct robustness analyses. Demonstrate feasibility via limited software simulations.

PHASE II: Develop working prototype radios based on the cross-layer protocols developed; demonstrate performance in a real-time environment.

PHASE III DUAL USE APPLICATIONS: The wireless medium is continually challenged by demands for new services. It is expected that emerging technologies will lead to significant decrease in the size, weight, and power (SWAP) requirements of sensors, as well as their cost. Hence, systems with possibly large numbers of embedded sensors will be developed and will play significantly increased roles in applications ranging from monitoring (traffic, habitats, factory floors), telemedicine, ensuring infrastructure integrity (roads, bridges, power plants), as well as in tactical battlefield communications (sensor networks are envisaged to have a key role in FCS). Constraints on bandwidth and power will become more severe as the demand from applications increases. Successful cross-layer radio designs should lead to efficient usage of bandwidth and power. Radio architectures with energy efficient medium access protocols coupled with low-complexity signal processing at the physical layer will thus be in demand in many commercial situations. Thus the development of novel cross-layer protocols for radios will have significant commercial potential.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Successful development of cross-layer protocols should lead to efficient use of bandwidth, and thus savings in cost.

REFERENCES:

1) NSF/ONR/ARO-CTA Workshop on Future Challenges to Signal Processing and Communications in Wireless Networks, 5-6 September 2002, Cornell University, Ithaca, NY.
2) NSF/ONR Workshop on Cross-Layer Design in Adaptive Ad Hoc Networks: From Signal Processing to Global Networking. 31 May - 1 June 2001, Cornell University, Ithaca, NY.
3) Special Session on Cross-Layer Issues, Asilomar Conference on Signals, Systems and Computers, 3-6 November 2002, Pacific Grove, CA.
4) A. Swami and B. M. Sadler, "Issues in military communications", IEEE Signal Processing Magazine, 16(3), 31-33, March 1999.


KEYWORDS: Sensor networks, wireless communications, cross-layer designs.

A03-036 TITLE: Human Behavior Architecture Interface for Integrated Cognitive and Task Performance Model Development

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Future Combat System

OBJECTIVE: In order to account for the full range of soldier performance expected under the Army's Objective Force vision, a single interface must be developed for modeling both cognitive and task behaviors. The Future Combat System and the Objective Force Warrior acquisition programs are relying heavily on simulation-based acquisition and "Human Systems" are listed as a key enabling technology for those programs. It follows, then, that human behaviors as diverse as commander decision making, the monitoring of robotic devices, soldier situation awareness, and the performance of combat tasks must be represented in Army models and simulations. The most urgent need is for models and simulations used in force design and system acquisition although testing and training models also share this requirement. So that behaviors are considered in appropriate combinations, it is critical that a unified framework and a single software interface exist for model development. Consideration of task-level behaviors separate from the underlying cognitive processes can lead to inadequate organizational and design solutions and also duplication of effort. What is required by the rapid pace of the Army Transformation is that new, efficient, and cost-effective technical solutions be developed for the representation of human performance in models and simulations. The type of innovative solutions sought would increase the accessibility of tools and techniques for military force development and system design, and, therefore, also increase design effectiveness resulting in better system solutions for the Objective Force.

DESCRIPTION: As noted in the National Research Council review (Pew & Mavor, 1998), the state-of-the-art of modeling human and organizational behavior is lacking. Currently there are reasonable approaches for representing task performance, which are used broadly today for human engineering (e.g., Allender, 2001); however, they require further maturation to adequately support representation of highly cognitive activities. Also, the application of cognitive modeling architectures to Army issues is becoming more prevalent and their value for representing cognition and for predicting human error performance, and thus, for system design has been demonstrated (e.g., Kelley, Patton, & Allender, 2001). However, cognitive architectures are notoriously difficult development environments, requiring expertise in both computer and cognitive science. Technology solutions must be developed that combine the detailed and theoretically-driven power of cognitive architectures with the broad descriptive and explanatory power of task network modeling (e.g., Lebiere, Biefeld, Archer, Archer, Allender, & Kelley, 2002). Such solutions must be applicable to both standalone modeling and human behavior representations federated with other models and simulations.

There are multiple challenges to creating an interface for a human behavior architecture for integrated model development. First, selection of reasonable, robust, and validated available cognitive and task architectures for further development and/or integration is required given that development of an entirely new architecture is likely to be prohibitively costly and result in unnecessary duplication of efforts. Interface development must meet criteria of sound programming, efficient as well as psychologically plausible model-to-model communications, and, most importantly, inherent portrayal of a common foundation for representing both human cognitive and task-level behavior. In particular, this single, unified interface for accessing the cognitive and task architectures must meet standard usability guidelines for consistency, but it also must guide and compel users to develop unified models that use both the cognitive and task modeling functionality in appropriate and balanced combinations (e.g., Avraamides & Ritter, 2002; Taylor, Jones, Goldstein, Frederiksen, & Wray, 2002).

PHASE I: The Phase I product will include the identification of task performance and cognitive architectures suitable to serve as the foundations for a unified interface. The documented rationale will be theoretically-grounded in accepted psychological principles including, but not limited to learning, memory, recall, recognition, decision making, and performance under a variety of stressors and individual difference parameters. A concept will be developed and application to an Army Objective Force-relevant case will be shown to be feasible. Within these requirements, there is considerable room for innovation and scientific advancement.

PHASE II: At the conclusion of Phase II, a fully-capable unified interface for accessing task performance and cognitive architectures and for developing a seamless human behavior representation will be developed. Supporting experimental and field-practical findings will be provided showing that modelers are able to develop behavior representations of appropriate combinations of cognitive and task performance. Applications to both standalone and model federations are required.

PHASE III: Prospects for Phase III applications are numerous: equally as well as in the military, and, for the first time, cost-effective tools and techniques for representing cognitive and task performance will be available to other government, industry, and even academia. The National Aeronautics and Space Administration, the Nuclear Regulatory Commission, the Federal Aviation Administration, and the Department of Transportation could take apply the resulting innovations to their own research, development, and regulatory efforts. Applications to the information systems, telecommunications businesses, and medical equipment industry also could be immediate as could implementation as a research tool in universities and colleges.

REFERENCES:
1) Richard W. Pew & Anne S. Mavor, Eds. Modeling Human and Organizational Behavior. Applications to Military Simulations. National Academy Press: Washington, D.C., 1998.
2) Laurel Allender. Modeling human performance: Impacting system design, performance, and cost. In Proceedings of the Military, Government and Aerospace Simulation Symposium, 2000 Advanced Simulation Technologies Conference, M. Chinni, Ed., Washington, D.C., 2000, pp. 139-144.
3) Troy D. Kelley, Debra J. Patton, & Laurel Allender. Predicting situation awareness errors using cognitive modeling. In Proceedings of Human-Computer Interaction International 2001 Conference: (Vol. 1) Usability Evaluation and Interface Design: Cognitive Engineering, Intelligent Agents and Virtual Reality, Eds. M. J. Smith, G. Salvendy, D. Harris, R. J. Koubek. Mahwah, NJ: Lawrence Erlbaum Associates, 2001, pp. 1455-1459.
4) Christian Lebiere, Eric Biefeld, Rick Archer, Sue Archer, Laurel Allender, & Troy D. Kelley. IMPRINT/ACT-R: Integration of a task network modeling architecture with a cognitive architecture and its application to human error modeling. Proceedings of the 2002 Advanced Simulation Technologies Conference, Simulation Series Vol. 34 (3). San Diego, CA: SCS, April 2002, pp. 13-18.
5) Marios N. Avraamides & Frank E. Ritter. Using multidisciplinary expert evaluations to test and improve cognitive model interfaces. Proceedings of the Eleventh Conference on Computer Generated Forces and Behavior Representation, May 7-9, 2002, Orlando, FL, pp. 553-561.
6) Glen Taylor, Randolph M. Jones, Michael Goldstein, Richard Frederiksen, & Robert E. Wray, III. VISTA: A Generic Toolkit for Visualizing Agent Behavior. Proceedings of the Eleventh Conference on Computer Generated Forces and Behavior Representation, May 7-9, 2002, Orlando, FL, pp. 157-167.

KEYWORDS: human behavior representation, modeling and simulation, cognitive modeling, task performance modeling, cognitive architecture

A03-037 TITLE: Non-Fuel-Cell, Ultra-Low Emission/Signature Engine Capable of Exhaust Water Extraction

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: NASA

OBJECTIVE: Develop non-fuel-cell propulsion engines/concepts with ultra-low emissions (both pollutants and heat), that are amenable to exhaust water extraction.

DESCRIPTION: The propulsion engine for advanced versions of the FCS (Future Combat System) must have many diverse attributes. Besides compactness, high power density and high efficiency, the engine must have the lowest possible pollutant and thermal signatures (both of which can be detected on the battlefield). In addition, in remote areas of the world, the ability to extract water from the engine exhaust is very desirable. Since (in an ideal combustion process) every gallon of fuel produces approximately an equal quantity of water, the ability to extract water from the exhaust would greatly reduce the logistics burden of delivering large quantities of water to the battlefield.

The described, desirable attributes could, perhaps, be met via fuel cell powered systems. While such (fuel cell) systems are already being examined under on-going programs, it is not obvious, at this time, that a fuel cell system will be able to meet the expected, difficult engine compactness and power density goals. Therefore, this solicitation seeks new, innovative ideas/concepts and/or modifications to conventional (e.g., internal combustion, or gas turbine) heavy fuel engine cycles which will result in the following desired attributes: 1) high fuel efficiency; 2) high power density; 3) ultra low signature; and 4) water recovery potential which does not compromise the power density of the engine.

PHASE I: The proposer must demonstrate a thorough understanding of conventional, heavy-fuel engine cycles. The proposer must also demonstrate the ability to analytically model his/her proposed concept(s), and show understanding of the underlying physical principles.

In Phase I the proposer shall demonstrate (analytically, or, preferably, via experiments) the feasibility of his/her approach to meet the program goals of ultra-low engine pollutant and thermal emissions, along with the ability to condense water from the engine?s exhaust. The proposed water extraction mechanism must not compromise the power density of the engine. The proposed concept(s) must be based on variations of, or modifications to, conventional (e.g., internal combustion, or gas turbine) heavy fuel engine cycles. Proposals based on fuel cell technology are specifically excluded from this solicitation.

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: The proposer shall design, build and test his/her engine concept and conclusively quantify reduced engine pollutant and thermal emission levels. The proposer shall also demonstrate and quantify the ability to extract water from the engine's exhaust.

PHASE III DUAL USE APPLICATIONS: Engines with ultra-low emissions and the ability to extract water from the exhaust have many uses besides powering Army vehicles. The described attributes are ideal for military and/or civilian power generation at remote sites, for both large, fixed- site, as well as for small, portable, distributed power applications. The ability to extract water is also ideal for ship-board propulsion or power applications.

REFERENCES:
1) Panting, J. R., “Optimizing the Super-turbocharged Aeroengine”, Professional Engineering Publishing Limited, 1998.
2) Acurio, J., “Small Gas Turbines in the 21st Century”, Tenth Cliff Garrett Turbomachinery Award Lecture”, SAE SP-981, 1993.

KEYWORDS: Heavy-Fuel, Propulsion, Emissions, Water Extraction

A03-038 TITLE: <u>True Time Delay Multiple Beam Antenna System Design Tool</u>

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: Space & Terrestrial Communications Directorate

OBJECTIVE: To develop an integrated electromagnetic simulation and computer aided design (CAD) software package for multi-wavelength structures that enables the user to complete an end-to-end design for true time delay multiple beam antenna systems.

DESCRIPTION: Multiple beams and electronic scan over a broad band offer significant improvements in system performance for future Army combat system applications. Millimeter wave frequency operations (i.e., Ka-Band) of such systems are desirable for many operational applications. True time delay beam forming networks, such as a Rotman lens, can provide multiple beams over a wide instantaneous bandwidth. However, the current state of the art in electromagnetic simulation tools does not provide a single synthesis, design, analysis, and layout tool for multiple wavelength structures such as a Rotman lens. An integrated software package capable of handling multiple wavelength structures, where different scales of the structure are modeled using an appropriate numerical technique (i.e., method of moments (MoM) or finite element method (FEM) for small scales, and physical optics (PO) or geometrical optics (GO) for larger scales), as well as a CAD output capability such as generation of a dxf file is desired. Commercially available products should be leveraged as much as possible to reduce the development time and cost.

PHASE I:  Develop a baseline for the integrated numerical techniques for multiple scales in a structure, demonstrate the capability of the design tools, and their functionality with the CAD environment.

PHASE II:  Advance the baseline design tools by leveraging commercial products and demonstrate the functionality of the final product by the design of a stripline Rotman lens.

PHASE III:  The development of the simulation package capable of multi-wavelength applications will significantly reduce the design time and cost for complex structures such as Rotman lens antennas, which has been receiving attention from military (i.e., Multi-Function Radio Frequency System) and commercial applications (such as multiple beam satellite communication systems).

REFERENCES:
1) B. Scheiner et al, “Architecture of a Multi-function System Based on Army Requirements,” 26 June 2002, 48th TSRS, Monterey, CA.
2) E. Adler et al, “Low-Cost Technology for Multimode Radar,” IEEE AES Magazine, June 1999, pp. 23-27

KEYWORDS: antenna system, electronic scan, multibeam, multi-wavelength, radar, communication, electromagnetic simulation, CAD, FCS, MMW

A03-039 TITLE: High Energy, Fast-Rise Film Capacitors

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE:  Develop materials and technology for film capacitors to be used in pulse-forming networks for electromagnetic defense and electric weapons.

DESCRIPTION:  For the applications mentioned above, a single capacitor may be of 100-1000 joules capacity with a voltage of 1 kV when fully charged.  A rise-time of <100 microseconds and an energy density greater than 2.5 J/cc are required, with good charge retention.  The present baseline capacitor provides 0.6 J/cc and utilizes polypropylene film.  Such film provides a dielectric strength of 700-1000 V/micrometer and a dielectric constant of 2.2.  What is required is identification/development of a new dielectric film material with higher dielectric strength and/or dielectric constant and associated manufacturing technology, including impregnants, surface treatments, metallization, etc., to accomplish high energy density, fast rise-time, good charge retention, high reliability, etc.

PHASE I:  Prove feasibility by identifying a new film material and demonstrating dielectric properties required for the applications mentioned above.  The research can include development of impregnants and other associated technology and/or the demonstration of a scaleable laboratory prototype capacitor.

PHASE II:  Develop all required technology for the capacitor requirement and demonstrate a scaleable capacitor.

PHASE III DUAL USE APPLICATIONS: High potential for use in compact defribrillators, other medical electronic implants, electric utility energy storage, filtering component for a variety of civilian electronic circuits.

REFERENCES:
1) LAGHARI J R, IEEE T NUCL SCI 39 (1): 21-24 FEB 1992 .
2) Andreyev A M, IEE P-SCI MEAS TECH 147 (2): 95-96 MAR 2000.

KEYWORDS: film capacitor, dielectric film, energy storage capacitor, capacitors

A03-040 TITLE: Mixed Signal for Multifunction RF (Radio Frequency) Sensor

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The Army has a documented need to develop enabling RF technologies that are both affordable and flexible with growth potential to address many radar and communication requirements. An area that best demonstrates a need for both affordable and flexible technology is in the transmitter architectures. Digitally generating highly complex wide bandwidth waveforms at the highest possible frequency instead of down near baseband would considerably reduce the transmitter architecture in terms of size, weight and power requirements as well as cost. These waveforms are used for high range resolution radars in sorting targets from clutter and low probability of intercept communication applications.

DESCRIPTION: A digital synthesis approach operating at carrier frequencies of greater than 10 GHz and bandwidths of greater than 1 GHz would greatly reduce transmitter complexity while improving the opportunity to pursue more multi-purpose RF sensors. Another issue to be addressed is spectral purity in which a goal of greater than 60 dB over the modulation bandwidth is suggested. Waveform configurations should include chirp, step frequency, phase modulation, limited impulse, pulsed RF and other hybrid modulations.

PHASE I: The goals for a Phase I study should explore the feasibility of emerging technologies (e.g., sigma-delta) that can meet the above specifications. Highly linear ultra fast D/As, integrated control and memory, and modularize construction (e.g., VME/VXI/PCI).

PHASE II: Design, build, test, deliver and report on the chosen synthesis approach. Performance as well as addressing affordability should be the emphasis of this effort.

PHASE III DUAL USE APPLICATIONS: High potential in many commercial RF systems, like satellite HDTV, air traffic and weather radars and other wireless communication networks.

REFERENCES:
1) M. Conn, E. Adler, R. Innocenti, “Digital Excitation and Signal Extraction for Modern Low-Cost Radars

KEYWORDS: direct digital synthesis, sigma delta

A03-041 TITLE: Efficient Atmospheric Extinction Algorithms for Line of Sight Transmission

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO-C3S

OBJECTIVE: Develop rapid and efficient algorithms, and implement modular computer software to allow calculation of Beer's law atmospheric transmission losses for path segments near the earth's surface, for infrared window bands.

DESCRIPTION: Parameterized approximations to the obsolete LOWTRAN transmission model are being used to calculate line of sight transmission losses in target acquisition software. The current MODTRAN software has implemented a new correlated-k capability that could be used to provide Beer-Lambert law compatible extinction coefficients suitable for calculating transmission loss for a series of path segments through a layered atmosphere describing the temperature, pressure and humidity structure. In order to provide rapid calculations in deployed target acquisition and mission planning software an optimized set of wavelength intervals covering the visible, near-, mid-, and far-infrared atmospheric windows is needed. The atmospheric transmission for these intervals can then be captured in a new parameterization with only a few terms suitable for representing transmission for sensor wavebands. These atmospheric transmission models must be suitable for covering a layered atmosphere extending from sea level to 15 km in addition to horizontal and near-earth paths and path lengths ranging from 100 meters to 50 kilometers.
The goal is an accurate (within 2%) fast running (100 times faster than MODTRAN's 1-inverse cm resolution) calculation capability.

PHASE I: Demonstrate the feasibility of a fast running transmission calculation by generating accurate Beer-Lambert law compatible representation of the mid IR (3.0 -- 5.0 micron) atmospheric window region. Quantify the number of sub-bands required, and their individual contribution to the total error budget. Develop an efficient implementation of a parameterization of the optimized band calculations suitable for use in a line of sight ray tracing application.

PHASE II: Extend the process to cover other atmospheric window regions (vis, near and far IR).
Potential benefits for the government and contractor are demonstrated through a full understanding of the optimization process documented in detailed reports and/or prototype software implementations.

PHASE III: The resulting analysis tools will be valuable in speeding up and simplifying weather dependent atmospheric transmission effects calculations needed for determining sensor coverage or placement decisions for other military or commercial surveillance applications. It may also be adapted to modeling of infrared imaging simulations.
The resulting phase 3 products will be a valuable analysis tool used by designers and analysts to include atmospheric transmission effects in system design efforts such as simulation based acquisition for the Army's Future Combat System multi-sensor trade-off.

REFERENCES:
1) Bernstein, L. S., A. Berk, P. K. Acharya, D. C. Robertson, G. P. Anderson, J. H. Chetwynd and L. M. Kimball, Very Narrow Band Model Calculations of Atmospheric Fluxes and Cooling Rates, Journal of Atmospheric Sciences, Vol. 53, No. 19, pp. 2887-2904 (1996).

KEYWORDS: Atmospheric Transmission; MODTRAN; Target Aquisition Weather Software TAWS)

A03-042 TITLE: Agent-Based Knowledge Enablers for the Unit of Action

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Development of tools and methodologies to support network centric warfare (NCW) that effectively target software agents technology against the critical information requirements associated with the Army’s Unit of Action (UA).

DESCRIPTION: A key tenet to NCW is the translation of information superiority to combat power [1]. With that, the US Army has euphemistically traded 70 tons of rolled homogeneous steel for 70 tons of information. Consequently, tomorrow’s digitized battlefield will not only provide unprecedented access to data and information, but threatens to overload commanders and staff with this information [2]. One of the challenges to effective NCW is the development of systems that will provide accurate, relevant and timely information to the right entities at the right time. Knowledge is the key enabler of the Objective Force [3].

The scope of this effort is the development of an agent-based system that improves a commanders ability to collect, process, manage and answer the critical information requirements (CCIRs) associated with a UA. CCIRs are designed to feed important, time-sensitive information to the commander so important decisions can be made that dramatically affect the fight. Needed are improved methods in retrieving and disseminating data, information and knowledge across the battle functional areas (BFAs) that do not require direct user intervention. Structured and semi-structured data sources from across disparate sources will need to be monitored, filtered, and fused against the CCIRs with appropriate alerts given the UA commander/staff. Areas of related research include: clustering and categorization algorithms, advanced data mining and fusion techniques, adaptable human-computer interfaces, dynamic ontology development, and knowledge management.

PHASE I: Identify and document a systematic approach for codifying and capturing the CCIRs against selected major sources of information. An appropriate data representation (ontologies) and agent architecture will be designed and proof-of-concept demonstrated.

PHASE II: Design, build and demonstrate a prototype agent environment that fully demonstrates the monitoring and management of all battlefield functional information sources against a UA's CCIRs.

PHASE III DUAL USE APPLICATION: The system will be integrated with current Future Combat System/Objective Force systems and provide real-time data monitoring/filtering against the UA CCIRs. The development of an agent-based knowledge discovery system that operates across disparate sources of information would have huge applicability for the commercial market.

REFERENCES:
1) David Alberts, John Garstka, Frederick Stein, Network Centric Warfare, CCRP, July 2002.
2) NATO Research & Technology Organization Report 8, "Land Operations in the Year 2020 (LO2020)", March 1999.
3) Battle Command O&O (draft) -- Annex D Appendix D, 14 Jun 02.

KEYWORDS: Software Agents, Knowledge Discovery, data fusion

A03-043 TITLE: Natural Hearing Restoration for Encapsulating Helmets

TECHNOLOGY AREAS: Human Systems

OBJECTIVES: Develop a system that will restore natural hearing to a soldier wearing a fully encapsulating helmet.

DESCRIPTION: Current designs for future Army's helmets, e.g., the Objective Force Warrior (OFW) helmet, focus on a fully encapsulating helmet integrated into the war fighter ensemble. It has been historically shown that soldiers performing tasks that require listening for auditory queues will doff their helmet so they can use their own natural hearing to its fullest capability. Directional information about the dynamically changing acoustic environment is critical to their mission execution and force protection. Encapsulation of the soldier's head will greatly reduce their situational awareness and thus their ability to complete their mission. The hearing restoration system can be integrated into or developed as a part of an encapsulating helmet. A soldier wearing this system would perceive the acoustic environment around himself or herself as if they were hearing it without a helmet. The system is intended to restore natural listening ability of the soldier wearing an encapsulating helmet without affecting the ballistic or Nuclear Biological and Chemical (NBC) protection provided by the helmet.

Restoration of natural hearing can be accomplished by physical design or electrical means. Special molded forms or microphones or microphone arrays can be used to capture the surrounding acoustic environment. The sounds from these systems can be further processed or filtered to restore the effects of the soldier's head and torso on the received natural sounds. The particular avenue for development of the acoustically transparent helmet is left up to the contractor. Additional capabilities of the system such as noise reduction and selective signal filtering should be considered if feasible.

Along with development of the system, the contractor will also devise a test to measure the attenuation, speech intelligibility, and signal localization of their system in realistic noise conditions. The test data should include bare head and un-restored encapsulating helmet measurements for comparison. The contractor may perform these tests in-house or use government furnished equipment and expertise.

PHASE I: Develop and provide a working concept demonstration of natural hearing restoration. The demonstration can use proprietary or commercial off the shelf (CoTS) devices. Deliverables shall include a written report that includes the expected values of signal loss (attenuation), speech recognition and sound localization of the proposed system as compared with bare head measurements. As a minimum, the proposed design should provide significant performance improvement over the un-restored encapsulating helmet with the bare head measurements being the goal.

PHASE II: Develop and demonstrate a cost effective prototype system that incorporates the findings from phase I into an encapsulating helmet. The government can provide the encapsulating helmet if so required. Deliverables at the end of this phase will include the prototype system and technical documentation describing the system and providing operational data.

PHASE III: Integrate the prototype system into the current OFW encapsulating helmet. This phase will include utilizing mil spec components, ruggedizing any of the hardware, and miniaturizing the system. Devise and execute testing procedures to evaluate the subjective and objective measures of the system including attenuation of the restored sounds, helmet attenuation of natural sounds, speech recognition, and degrees of accuracy of signal localization in azimuth and elevation.

DUAL USE APPLICATIONS: There is a current need in military and civilian applications for the development of a system that restores natural hearing in an encapsulating helmet. The OFW has a current specification for an encapsulating helmet. This system can also be used for civilian operations such as HASMAT operations and search and rescue where the operators are wearing head encapsulating gear.

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KEYWORDS: Natural Hearing, Encapsulating Helmet, Sound Localization

A03-044 TITLE: Polymers for Lightweight Small Arms Cartridge Cases

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Joint Services Small Arms Program (JSSAP) Office

OBJECTIVE: The objective is to assess the performance of polymer materials or filled-polymer systems, exposed to a range of environmental conditions, when used as a cartridge shell casing that is subjected to normal feed, firing, and extraction operations.

DESCRIPTION: The U.S. Army currently utilizes brass as the material of choice for cartridge cases for small caliber (5.56mm and 7.62mm) ammunition. Significant weight savings could be attained if a lightweight material were substituted for the cartridge shell body. These rounds are widely used in a variety of weapon systems and any material or design changes must be such that no modifications to the weapon system are required.

PHASE I: Propose and assess candidate materials capable of withstanding all the various load conditions experienced by a 5.56mm cartridge case. Guidelines for appropriate polymer materials include a minimum Tg of 150º C, a modulus reduction of less than 15% over the temperature range of -55º C to 65º C, and water uptake of less than three (3) weight percent at room temperature saturation. At a minimum during Phase I, coupon testing of samples shall be done to fully characterize candidate materials mechanical and thermal properties to assess their utility in a cartridge case application. Development of this material property database will provide information to allow for determination of the feasibility of a given material for cartridge applications. Also, processing issues related to the level of effort and cost associated with producing a particular candidate material in a cartridge-like configuration should be addressed.

PHASE II: Demonstrate the feasibility of candidate materials with appropriate sub-scale testing that simulates extraction loads on the cartridge base, feed loads on the cartridge neck, and the internal pressure loads imparted on the cartridge body. Design and fabricate demonstration rounds that are 35% less massive than the complete round weight of the M855, 5.56mm cartridge case while providing at least 90% of the internal volume currently available for propellant in the M855. The rounds should then be experimentally tested under a variety of environmental conditions that mimic the service environment. This should, at a minimum, include subjecting materials to long-term exposure to moisture, as well as examining performance when thermally conditioned at hot (65º C) and cold (-55º C) temperatures prior to firing.

Phase III: Material solution may be applied to various small and medium caliber munitions, including 5.56mm, 7.62mm, and 50 cal.

DUAL USE COMMERCIALIZATION: Development of composite cartridge shell cases would have application to other caliber ammunition that is sold commercially for use by police and security agencies. The technology would also be applicable to the sporting goods industry for use by hunters and target shooters.

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KEYWORDS: polymer, cartridge case, small caliber weapon, medium caliber weapon

A03-045 TITLE: Configurable Tooling Systems for Complex Structures for Objective Force Survivability

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The need for optimized materials performances to meet ballistic damage tolerances in multifunctional materials has lead to a number of challenges in the fabrication of test articles for ballistic structures. A significant limitation of fabrication methods is the ability to adapt tooling to meet applicable uses and achieve high mechanical tolerances when switching between liquid molded and bonded ballistic structures and woven prepreg with bonded structures. It has been observed that tolerance variations in materials designs can lead to substantial changes in performance in a ballistic environment. Further, the additional need to replace damaged ballistic sections in the field environment require equivalently high tolerances, which will be difficult to achieve using current molding technologies, and decrease survivability and effectiveness of repaired ballistic structures. Current technologies are not available for rapidly developing replacement components at the depot level to sustain composite platforms. One solution could involve rapid prototyping and tooling technologies that could be implemented during fabrication and replicated for depot level to allow multiple technical components to be prepared in a single tool. The complexities of polymer matrix composites for ballistic structures have demonstrated that custom tooling or fixturing is required for vehicle surfaces, substructure, panel and hatch development, repair, and replacement. The time and cost burdens of these activities, even with traditional molding technologies, can often involve modification or repeated tool fabrication before the activity is completed. Currently available configurable tooling solutions do not allow fabrication of multiple material forms on a single platform, driving up development costs in the search of survivable structures. Further, whether the final tool set is for a single use or for repeated use, there are additional cost burdens for disposal or storage and maintenance of the tool sets.

DESCRIPTION: The Army is seeking innovative approaches that will significantly increase production rate and reduce program costs for vehicle structure developments and designs. Ideal tooling solutions might furnish "universal" tooling capabilities. For example a reusable, reconfigurable or reformable tooling system could: 1) take a precise and accurate impression from a master-qualified composite part; 2) provide a hardened tool that has physical properties tailored to reproduce the part from a variety of polymer-matrix composite materials systems; and 3) enable the hardened tool to be returned to a reformable, impression-taking condition after the production of one or more parts which are identical to a master-qualified replacement part.

A universal tooling system would meet the following criteria: 1) aid fabrication of parts at any scale, from 10 centimeters up to 10 meters in length/width/depth; 2) replicate compound-curved or complex shaped parts such as vehicular panels (hoods, doors, bumpers) or integral ribbing with corner radii of less than 10 millimeters; 3) be suitable for removable mandrel, insert or trapped-tool applications as for the repair or reconstruction of ducting or ribbed structures; 4) be durable enough to hold precise tolerances during hand fabrication and debulking processes including prepreg, roving, knit and woven material, and VARTM; and 5) tolerate, without deterioration, cure cycles of up to 375F.

PHASE I: Demonstrate, at laboratory or benchtop scale (10 centimeters minimum length/width/depth), approaches to creating one or more tooling material systems that can be formed into precise negatives of test shapes, that can be hardened to produce usable tools that will not degrade or lose tolerances under vacuum bag infusion processing. The tool should be returned to formability and be capable of repeated (>50 cycles) form/reforming without degrading or losing properties of conformability.

PHASE II: Develop and demonstrate a prototype tooling system which replicates a master-qualified composite part, in a composite materials system requiring autoclave cure up to 100PSI and 375F, with dimensions of 2 meter minimum for length and width, with one foot depth.

PHASE III: Phase III will require DoD component sponsorship. For successful advance to this phase, a successful Phase II proof-of-concept must have been demonstrated, and the program sponsor for this SBIR effort will have coordinated transition to demonstration/validation. The contractor must support a successful Phase III transfer by maturing the tooling system to a point for commercial viability including manufacturability and cost.

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3) G. Thomas, "Manufacturing Affordable Composite Structures for Ground Combat Vehicles, Defense Manufacturing Conference 1999, Session IV, Miami Beach, FL, 29 November - 2 December 1999.
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KEYWORDS: composite fabrication, vehicle armor, configurable tooling

A03-046 TITLE: <u>Breathable, Chemical Resistant, Elastomeric Protective Clothing Material</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design, synthesize, fabricate and evaluate an economical and lightweight chemical protective clothing that demonstrates flexibility, durability, and selectively permeable properties.

DESCRIPTION: The U. S. Army requires that all fielded systems be survivable in a chemical warfare environment. Butyl rubber is currently used for protective gloves because it is an excellent barrier material against chemical threats. Although butyl rubber is an excellent barrier, it does not allow water vapor transport needed for maximum comfort. Current protective clothing materials are based on activated carbon that is effective for chemical protection but can be heavy during long periods of wear, potentially placing a weight burden on the soldier. Outfitting the soldier in accordance with new Future Combat System (FCS) and Objective Force guidelines requires that the materials be lightweight and flexible, enabling the soldier to move freely. New advanced materials that are flexible, lightweight and selectively permeable will offer significant improvement in both reduced weight and reduced heat stress (increased water vapor transport) for the soldier. In an effort to address these multiple requirements, the Army Research Laboratory has developed a series of sulfonated tri-block copolymers. The novel polymers are comprised of polyisobutylene as a major component to afford inherent barrier properties to the block copolymer. The novel block copolymers exhibit flexibility over a broad temperature range and selectively permeable "membrane-like" characteristics. Although it is not required that a proposal for this solicitation specifically utilize the tri-block copolymer approach developed by the Army, this material is mentioned because it has shown some very desirable properties for breathable protective clothing such as high moisture vapor transport rates and flexibility at low temperatures.

PHASE I: Research efforts should focus on the design and synthesis of a copolymer/ionomer comprised in part of an impermeable block and an ionic block, that exhibit numerous properties that are critical for chemical protective field operations. These properties include: flexibility over a broad temperature range (~ -60ºC-100ºC), economical processing as membranes for coated or woven fabrics, gloves, tenting, or stacked fuel cells, exhibit high levels of water vapor transport and simultaneously block transport of organic compounds such as chemical warfare agents. Results from the Phase I effort should demonstrate the above characteristics and define a clear and feasible synthetic route that will enable production of the elastomeric membrane at the pilot plant level. The synthetic routes of preparing the polymer must be in accord with methods that are amenable to large scale domestic (U.S.) manufacturing facilities. That is, solvents used must be in compliance with environmental laws in the chemical and textile industries and an environmentally friendly route to manufacture such as water-based processing is preferred. Economic analysis shall be performed and outlined to determine the estimated cost to produce the membrane at pilot plant level. The elastomeric membrane should exhibit durability, flexibility and selective transport properties necessary for use in military field operations and chemical warfare environments. That is, the membrane should "breathe", allowing water vapor to transport away from the soldier, thereby reducing heat stress, while simultaneously blocking penetration of harmful substances in liquid or vapor form. Water vapor transport values should be as a minimum, competitive with commercially available "breathable" fabrics used for sports and recreation.

PHASE II: With candidate materials identified in Phase I, the Phase II program should address scale-up of the elastomeric membrane as woven textile, gloves, or tenting. The copolymer shall be used in the fabrication of prototypes to include a coated fabric or woven fabric outer garment and breathable, elastomeric chemically protective gloves. Testing of the prototypes will be performed to demonstrate flexibility, durability, breathability, and protection against actual chemical warfare agents. Detailed fabrication procedures for the prototypes shall be established. Economic analysis shall be performed to determine the cost of fabricating a full body protective suit for military applications, utilizing the polymer membrane. All processing and fabrication procedures must be in compliance with environmental laws in the chemical and textile industries.

PHASE III Dual Use Applications: Successful development of the polymeric membrane may have numerous applications as biomedical materials that require selective water transport (i.e., wound dressings) and as alternative fuel cell membranes. Economically feasible chemical protective suits would be useful in numerous. Industries that could potentially benefit from commercialization include companies that supply raw materials, block copolymers polymers and fibers such as Shell Chemical and Dupont Corporations.

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KEYWORDS: copolymer, membrane, ionomer, protective clothing, water transport, barrier, elastomer

A03-047 TITLE: Long Wave Infrared Acousto-Optic Materials

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO CHEM/BIO DEFENSE & NBC Defense Systems

OBJECTIVE: To develop novel materials for fabricating acousto-optic tunable filters in the 8-12 micron spectral region for multispectral and hyperspectral imaging applications as well as for remote sensing and monitoring of environmental pollutants and chemical and biological agents.

DESCRIPTION: The US Army Research Laboratory is seeking innovative approaches for the development of a no-moving-parts, electronically tunable spectral imaging system for 8 to 12 micron spectral region for a number of multispectral and hyperspectral applications for detection of targets, backgrounds, and stand off chemical and biological agents. Such a hyperspectral imager is based on using an acousto-optic tunable filter (AOTF). This long wave infrared (LWIR) technology is particularly relevant to detection of buried mines and is an essential part of achieving the hyperspectral imaging technology goals set in the Army's 3rd Generation Science and Technology Objective (STO). So far only a small number of nonlinear crystals have been identified that have high acousto-optic figure of merit and can be used in the fabrication of an LWIR AOTF. At the present time, only a couple of such crystals are grown (thalium arsenic selenide (TAS) and mercurous chloride) by a single source. In addition to the applications for designing AOTFs for high quality LWIR spectral imaging systems, there are a number of other commercial applications for designing active and passive optical components such as frequency doublers, polarizers, lenses, retarders, windows, etc. The first components of this work will be to develop novel anisotropic materials for designing AOTF cells operating in the long wavelength infrared spectral region (8-12 micron). These materials must be easy to work with, nonhygroscopic, have high acousto-optic figure of merit (M2), high birefringence, and relatively high transmission in the desired wavelength region. The second component will be integration of such AOTF cells with infrared imagers. Desired materials include tellurium, mercurous halides, and TAS.

PHASE I: Identify suitable materials, produce device quality material for the most promising candidate, study low-temperature properties of this material, and demonstrate an acousto-optic modulator in such a material for operation in 8 to 12 micron spectral region.

PHASE II: Optimize the growth parameters for candidate material, grow high quality crystals, fabricate an AOTF for operation in the 8 to 12 micron region at low-temperature, integrate this AOTF with high performance commercially available infrared imaging systems procured via government sources to demonstrate a hyperspectral imager operating in the 8 to 12 micron region with image processing capability. Delivery of an AOTF and high quality crystals is required.

PHASE III DUAL USE APPLICATIONS: Development of such material and devices is very important for a variety of civilian applications such as fabrication of various active and passive components as well as for applications in pollution detection, environmental monitoring and mapping, auto emission monitoring, better process and quality control in manufacturing of food, beverages, semiconductors, pharmaceuticals, petrochemicals, and better medical diagnoses.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Army can substantially reduce the cost of vehicle maintenance by real-time monitoring of exhaust plumes and the condition of engine oil. Also, the Army will have a no-moving-parts, compact multipurpose imaging spectrometer that so far does not exist.

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KEYWORDS: cousto-optical interactions; acousto-optic tunable filters, acousto-optical devices, long wave acousto-optic materials, tellurium, mercurous halides, thalium arsenic selenide, TAS, Hyperspectral imager, polarization imager, chemical/biological agent detection, mine detection

A03-048 TITLE: Ultra-Compact Doppler LIDAR (Light Detection and Ranging) for Unmanned Aerial/Ground Vehicles

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Design and build an ultra-compact, Doppler LIDAR (LIght Detection And Ranging) for use on medium to light unmanned aerial/ground vehicles that has multi-use capabilities for remote sensing of volumetric vector winds, topography, and aerosol plume detection.

DESCRIPTION: Recent advances in solid-state lasers and compact signal processing systems have made possible new, ultra-compact "pocket" LIDAR systems for remote sensing of the environment. In particular, the operational needs for eye-safety have led to development of low-energy, high pulse rate laser systems operating in the short-wave infrared region. The use of airborne Doppler LIDAR has been demonstrated but with LIDAR systems that were too large for most UAV platforms. The development of "pocket" LIDAR systems enables the technology for use on medium to lightweight UAV/UGV platforms that will be part of the Future Combat System. The use of airborne Doppler LIDAR for real-time detection of air hazards such as wind shear, microbursts, and clear-air turbulence will greatly extend airborne operations and capabilities.

PHASE I: Develop an overall system design for a "pocket" Doppler LIDAR that includes a specification for laser source, transmitter/receiver, detection system, and signal processing.

PHASE II: Develop and demonstrate a prototype "pocket" Doppler LIDAR system. Conduct feasibility study to determine effectiveness in UAV/UGV operations.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad-range of military and civilian applications where information of 3-dim winds and turbulence are necessary, such as: airport operations, clear-air turbulence detection in-flight, and pollution monitoring.

REFERENCES:
1) J. Rothermel, et. al., "Remote sensing of multi-level wind fields with a high-energy airborne scanning coherent Doppler lidar," Opt. Express 2, 40-50 (1998).
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KEYWORDS: lidar, remote sensing, battlefield environment, wind sensing, topographic lidar, aerosols

A03-049 TITLE: Blast and Shock Damage Analysis

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: To develop a method/tool to characterize equipment failure to high frequency shock environments.

This new tool shall be capable of analyzing full size equipment (that may be mounted inside a vehicle) to the effects of high frequency shock induced by a conventional blast/shock environment.

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 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 and shock 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 and shock effects will have a greater impact then ever before. A stand alone module that can determine the damage to vehicle equipment due to a blast/shock induced environment is needed to complete the overall MUVES-S2 modeling suite. Through physical damage, or functional loss, the degraded state of the impacted equipment will be used as input to the MUVES S-2 code for an overall system analysis.
The time duration for blast/shock environments of interest are typically in the range of .5 to 1.0 ms, with loadings in the range of several thousands of pounds per square inch.

PHASE I: 1. The contractor shall investigate the feasibility of a methodology/tool to determine the damage induced to Army equipment by a high frequency blast/shock environment. The damage can be either a physical damage or loss, or a loss of function of the equipment. The results shall be represented by an Equipment Fragility Spectra (EFS) as depicted in TM 5-855-1, or in a similar manner.
2. The contractor shall develop a preliminary version of this new method through the use of test cases and demonstrate how it can be linked to the MUVES S-2 computer code.

PHASE II: For Phase II, the contractor shall extend the Phase I methodology to the full capability of a productive tool for blast/shock analysis. The tool shall be capable of identifying the shock mitigation levels needed to reduce and/or eliminate damage and also be capable of using various shock mitigation values as input to the analysis. A complete verification and validation program should be incorporated in the development program with limited validation experiments being conducted to support the results. The contractor shall also demonstrate the prototype version on an actual Army system exposed to potential blast/shock environments. The new tool shall be a final design that meets the requirements set fourth in Phase I.

PHASE III DUAL USE APPLICATION: The new tool can be interfaced with the MUVES S-2 Computer code for greater survivability modeling for the Department of Defense. This new tool will also have a broad range of commercial applications. Not only will it directly impact blast/shock modeling capabilities, it will also enhance the commercial application of shock mounted equipment. Commercial sectors that will benefit from such a tool range from the airline industry to the computer industry. High frequency shock problems are becoming potential problems as equipment is more complex and lighter weight.

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:
(1) MUVES Software Manual, June 7, 2001,
(2) MUVES Analyst's Guide, May 27, 1994.

KEYWORDS: blast, shock, survivability analysis, MUVES S2, ballistic shock

A03-050 TITLE: Research and Development of Stochastic Optimal Control Algorithms for Mobile Communications Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The purpose of this SBIR is to solicit research and development of computational algorithms for stochastic optimal control of mobile communication systems with randomly time varying channels. The algorithms shall address the optimal energy-time allocation and admission control policies that maximize the expected system data throughput and minimize the expected system delay in a weighted combination manner.

DESCRIPTION: It is evident that the utilization of mobile communications systems has played a decisive role in the outcome of modern military operations at the tactical and strategic levels. In military applications, the communication channels of these systems are often randomly time varying and the arrivals of data are often random but bursty, partly due to the dynamic reconfiguration of transceivers in the battlefield environment (see [6], [7]). Due to the complexity of the physical problems, systematic and rigorous mathematical modeling and control of these networks are still in their infancy. Currently, the modeling and optimal control studies have only been done in an ad hoc manner for some simplified networks (see [3], [5]). In particular, heavy traffic and fluid flow analyses (see [1], [4]) have been used to provide diffusion approximations for some aspects of these problems and the dynamic programming principle (see [2]) has been used to characterize the optimal energy allocation and admission control policies for a simplified discrete-time satellite communication system (see [5]). The rigorous modeling and optimal control problems for the currently available commercial and military communication systems remain largely unsolved. Some important issues facing the military and industry include the effective management of these networks. These problems include the optimal energy and time allocation to the communication channels and the optimal admissible control of the channel users so that the mean data throughput will be maximized and the mean network delay will be minimized in a weighted combination manner. This SBIR topic solicits the application of research and the development of computational algorithms for the currently available optimal control policies in the form of computer software that can be implemented in the existing networks. The algorithms shall take into account partial as well as complete observable channel states and data queue size in each channel. The program is to be carried out in the following three phases.

PHASE I: Phase I of this SBIR project shall focus on the assessments, combinations, and extensions of currently available optimal energy and time allocation as well as optimal admission control policies that will maximize mean data throughput and minimize mean delay in a general continuous-time mobile communication network.

PHASE II: In Phase II, the following shall be done:
a. Design of computational algorithms in terms of temporal and spatial discretization schemes and establishment of its convergence for the results obtained in Phase I.
b. Analyses of error bounds and convergence rates for the computational algorithms.
c. Computer coding in the form of software for the algorithms obtained in this project.
d. Demonstration of feasibility and practicality of the prototype software developed for available commercial communication networks.

PHASE III DUAL USE COMMERCIALIZATION POTENTIAL: The research and development of new stochastic optimal control algorithms in real-time environment will contribute to the effective management of both military and commercial mobile communications systems. Specifically, the implementation of the end products of this project will have tremendous potential in increasing mean network throughput and decreasing energy cost and mean network delay. The awardee(s) shall have the copyright of the algorithms and software developed and shall have the responsibility for the commercialization of the products.

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communications satellites", IEEE/ACM Transactions on Networking, June 2002.
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KEYWORDS: mobile communications systems, heavy traffic, dynamic programming, optimal energy and time allocation, admission control

A03-051 TITLE: Mixed-Feed Direct Methanol Fuel Cell

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM Soldier Systems

OBJECTIVE: Develop a compact 20-W direct methanol fuel cell system that utilizes mixed-reactant feed of air + methanol (aqueous) to one or both electrodes of a polymer electrolyte membrane fuel cell. The system should include all balance-of-plant auxiliaries, such as fluid moving equipment, heat exchangers, and storage vessels. The power system should be compact (> 1 kW/L and >1 kW/kg), energy dense (> 1kWh/kg), and supply 1 kWh of energy.

DESCRIPTION: The Army has need for high-energy, lightweight power sources for the solider. Polymer electrolyte membrane fuel cells (PEM FCs) are candidates to fill these needs. Such FCs may be powered by direct electrochemical oxidation of methanol, a so-called direct methanol fuel cell (DMFC). In state-of-art DMFCs, an aqueous solution of methanol fuel is fed separately to the anode compartment of the FC and air (oxidizer) is fed to the cathode compartment. The two compartments are physically separated by the PEM, which is a barrier to bulk movement of liquid or gas in addition to its function as the electrolyte. In this cell configuration, a minimum of two fluid-motive devices are required (blower and pump), and heavy (and bulky) bipolar plates are used in the cell stack to prevent intermixing of the two reactant feeds. Recently, it was reported that a mixed-reactant feed of an aqueous basic solution of methanol and air fed to a cell without separator yielded polarization characteristics similar to that when the two reactant streams are not purposely mixed (1). It has also been reported that the performance of a single-cell PEM DMFC is enhanced by mixed-feed of air and aqueous methanol solution fed to the anode compartment (2). The efficacy of using innovative modes for mixed-reactant feed to a PEM DMFC stack is unexplored, and the system implications on requisite auxiliary components is unresolved. Examination of these issues is the focus of this SBIR topic.

PHASE I: Design, construct, and characterize a 20-W fuel cell stack that uses mixed-reactant feed of air + methanol (aqueous) to one or both electrodes of a polymer electrolyte membrane fuel cell that operates nominally at atmospheric pressure. Report voltage and power density as a function of current density at operating temperature. Define, explore, and discuss system concepts to be addressed in a Phase II effort with emphasis on those that are unique to mixed-reactant feed.

PHASE II: Using results from the Phase I effort and the Objectives stated above, design, construct, and evaluate a 20-W direct methanol fuel cell system based on mixed-reactant feed to the fuel cell stack.

PHASE III DUAL USE COMMERCIALIZATION: Developments in fuel cell power sources will have immediate impact on a wide range of commercial power sources from computer power to emergency medical power supplies to recreational power uses.

REFERENCES:
1) Priestnall et al., "Compact mixed-reactant fuel cells," J. Power Sources, 106 (2002) 21-30.
2) Shukla et al., "A solid-polymer electrolyte direct methanol fuel cell with a mixed reactant and air anode," J. Power Sources, 111 (2002) 43-51.

KEYWORDS: Fuel cell, soldier power, methanol, electrooxidation of methanol

A03-052 TITLE: Self-Decontaminating Coatings

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Identify and explore innovative paints or paint additives capable of detoxifying chemical and biological molecules on surfaces on a long term, sustained basis. Such a paint or paint additive must also meet present military specifications for coatings. The coating will preferentially reduce or eliminate the need for any additional decontamination procedures, and reduce or eliminate the risk of introducing additional pollutants into the environment. The coating will however be compatible with all presently used or contemplated chemical decontamination treatments. Such a paint or paint additive will weather with present military repainting schedules. It will have the potential to address as many threat agents as possible.

DESCRIPTION: Certain paints presently utilized by the U.S. Military address the problem of chemical agent contamination by using veneers that either shed or enhance removal of agent from surfaces. Decontamination procedures require additional manpower and materials, and in worst case scenarios actually introduce additional pollutants into the environment. Other surfaces painted by the armed services without the benefit of chemical agent shedding veneers, such as buildings, electronic equipment, etc. do not address chemical agent decontamination in any regard. The interiors of aircraft and vehicles are key areas where a reactive coating could be immediately used. Cost effective paints that decontaminate chemical agents and their residues on a wide range of surfaces painted by the military are needed. The references to this topic contain information on possible simulants for the chemical warfare agents. Decontamination contact exposure levels on the coating should be reduced at minimum to the following: Nerve-G, <16.7 mg/m2; Nerve-V, <0.78mg/m2; Blister-H, <100mg/m2.

PHASE I: Identify and demonstrate the ability of a coating or paint additive to detoxify a range of simulants of chemical warfare agents and toxic chemical and determine the capacity of that coating. Relatively toxic additives/catalysts are less desirable for a coating. This part of the effort should provide evidence that their concept is viable.

PHASE II: Conduct testing to demonstrate real-world utility of the coatings on different surfaces and equipment and their effectiveness against chemical agent simulants and if possible live chemical agents. Characterize the new coatings with respect to traditional means of evaluations for example durability, gloss, and flex among other tests.

PHASE III DUAL USE COMMERCIALIZATION: A simple to use and apply protective coating has numerous applications in the military and domestic preparedness community. A reactive coating can be used for protection in the event of a domestic terror attack with chemical agents or for protection in an industrial accident. Public buildings, monuments, and military facilities could use the coatings in a preemptive nature to protect national assets. Demonstrations of live agent capabilities in operational settings in phase III is appropriate.

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1) Yu-Chu Yang, James A. Baker, and J. Richard Ward "Decontamination of Chemical Warfare Agents", Chem.Rev. 1992, 92, 1729-1743.
2) Yu-Chu Yang "Chemical Detoxification of Nerve Agent VX" Acc.Chem.Res. 1999, 32, 109-115.

KEYWORDS: coatings, decontamination, reactive coating, chemical warfare agents

A03-053 TITLE: Detection of Drugs/Narcotics and Processing Components Using "Sniffing" Devices

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: Develop innovative "sniffing" sensor devices for the detection of drug/narcotics or the compounds used to render them, characterize specific chemical compounds, time-stamp the detection, and perform some elementary function to identify the occurrence. The envisaged devices are small, lightweight, and operate under no power or their own on-board low power (e.g., small battery). They can be easily inconspicuously placed in the field or can be hidden. The sensor suite will be combined initially with a readout system that permits on-site inspection of the device. Later versions of the system will be able to transmit needed information to a command center in near real time through adverse environmental conditions, such as triple canopy tropical foliage.

DESCRIPTION: Sniffing technologies have demonstrated potential for locating the existence of "out gassing" explosive chemical compounds and these technologies have the potential to be extended to develop "sniffers" for other chemicals. This innovative and creative approach has the potential to establish and validate a suite of sensors and their characterizing algorithms to detect, analyze, and report movement of drugs and drug rendering chemicals as part of point and area surveillance programs. The system may be based upon multiple integrated or single detector elements and/or chemical reaction devices. Sensors should be inconspicuous and initially deployed by hand. A mission life of no less than 180 days is desirable, and the system should allow for retrieval. The sensor suite should require no power or carry it's own power, be self-organizing and provide continued operation in the event that an individual detector becomes inoperable. Sensors/algorithms and communications should be transferable to allied foreign entities for emplacement and monitoring.

PHASE I: Demonstrate a laboratory prototype sensor mix and algorithms to detect the presence of specific chemical compounds associated with drug/drug producing compounds. The prototype shall demonstrate the ability of the final product to meet the requirements of small size, light weight, operation without an external power source and the capability to detect the chemical(s) of interest. Identify path for optimization in potential follow-on work and show expected probability of detection versus false alarms. Also, identify a device "reading" capability, or communication system – sensor combination that permits transmission to a command center in near real time under adverse environmental conditions.

PHASE II: Optimize, assemble, and test a sensor suite that is lightweight, inconspicuous and meets conditions of deployability, self-configuration, and does not require an external power source. The system should have high probability of detection with low false alarms. At end of Phase II, system should be available for testing by DOD personnel. Investigators may assess and analyze the effectiveness of single, and multi-technology devices for detecting and characterizing nearby chemical signatures.

PHASE III DUAL-USE APPLICATIONS: Phase III work would involve development of ruggedized sensors for actual deployment. Different sensor suites may be developed to allow for changing scenarios. Intelligence and homeland defense applications could directly benefit from having a standoff detection device for counterdrug activities as well as terrorist movements along land and water lines of communications in both the US and allied nations.

OPERATING AND SUPPORT (O&S) COST REDUCTION (OSCR): Optimized sensors will be more reliable and will have a faster response time, and provide a substantial force multiplication factor by using machines instead of humans to monitor water borne activities

REFERENCES:
1) Catalytic buffers enable positive-response inhibition-based sensing of
nerve agents, Alan J. Russell, Markus Erbeldinger, Joseph J. DeFrank, Joel Kaar, Geraldine Drevon Biotechnology and Bioengineering Volume: 77, Issue: 3, Date: 5 February 2002, Pages: 352-357.
2) Fluorescent Porous Polymer Films as TNT Chemosensors: Electrnoic and Structural Effects, Y-S Yan and T.M Swager, J. Am.Chem.Soc. 1998, 120, 11864-11873.

KEYWORDS: Surveillance, algorithms, networked sensors, drugs, narcotics, drug laboratory, infrared, olfactory

A03-054 TITLE: Large Scale Biomaterial Production

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this SBIR is to develop and exploit technologies for the very large-scale production of transgenic protein fibers in a cost-effective robust plant, microbial or animal system. Suitable quantities would be produced for manufacturing protective clothing, body armor, surface coatings, wound healing protectants, bioartificial grafts, or other applications requiring large quantities of material.

DESCRIPTION: Biological materials have evolved very specialized roles as a consequence of four billion years of natural selection and adaptive mechanical design. These "smart" products have properties of durability, strength, stiffness, toughness, reliability, resilience, self-assembly, and biodegradability. Such attributes can be modulated independently to achieve a distinctive biological function. Protein fibers, that have evolved to perform extraordinarily diverse structural and physiological functions, are synthesized from a pool of twenty low molecular weight renewable precursors, amino acids, in an aqueous environment at ambient temperatures. The high efficiency and unique functionalities of these fibers are achieved by the distinctive sequences of the amino acids in the assembled proteins. For military and civilian applications, advantage can be taken of the billions of years of natural selection that evolved proteins with unique structural, mechanical, or physical properties. By molecular biological manipulation of the amino acid sequences, proteins with altered characteristics can be produced. However, while these proteins can currently be produced in sufficient quantity for research and medical applications, the current production technologies are not economic enough to provide the tons of material necessary for widespread DoD and civilian use. The major impediment to exploiting these natural or genetically altered substances is the inability to economically produce the material on a large scale.

This SBIR solicits the research and development of protein-producing systems that have the capability of generating very large quantities of specific transgenic proteins. Heretofore, most recombinant proteins have been produced in small, expensive bioreactors, producing relatively small quantities of the specific protein. The product often was deposited in inclusion bodies, making it difficult to purify and reconstitute to its native properties. The plant, microbial, or animal system that would be developed under this SBIR should be versatile, robust, and cost-effective. Properties of the system would include stability of the structural gene for the protein being produced, minimal toxic effects of the protein product on the host system, limited degradation or post-translational modification of the product, and easy recoverability of the product. The system also should be sufficiently versatile to be capable of being engineered to manufacture a diverse series of recombinant proteins.

Examples of proteins that could be produced include, but are not limited to, collagens, glycoproteins, elastin, proteoglycans, keratins, viral capsid proteins, actin, tubulin, and various silks. These have applications in fabricating tendons for muscle repair, contractile proteins for unique mechanical properties, structural proteins with strength and resilience for protective clothing, smart proteins for self-assembly systems in producing complex protein composites, filamentous proteins for capture systems of high strength and durability, and the production of bioartificial grafts.

The technology to be developed under this SBIR would have many advantages over most current systems in that a product would be produced in sufficient quantity and purity for high volume applications. Products, systems, or composites that exploit the native or genetically altered properties of the transgenic proteins could be produced to protect the warfighter, and in a multitude of military and civilian applications. In addition, sufficient materials could be produced to allow research in the development of innovative fibers such as: highly thermostable proteins; protein systems mediating oxidation:reduction processes or electronic conduction; proteins with unique and reversible adhesive properties, etc.

PHASE I: The output of phase I will be a report summarizing the data on the flexibility, production capacity, and cost of the proposed bioproduction system, and a comparison of the merits of the proposed system relative to other bioproduction systems.

PHASE II: The investigators will establish that the system is stable, specific, and reliable in producing large quantities of recombinant proteins by producing a large amount of a bioproduct.

PHASE III: This technology could be licensed to other companies seeking to produce large volumes of biomaterials at low cost, to produce a variety of products that are currently uneconomical to produce. Potential products include: tendons for muscle repair, contractile proteins with unique mechanical properties, structural proteins with strength and resilience for protective clothing, smart proteins for self-assembly systems in producing complex protein composites, filamentous proteins for capture systems of high strength and durability, and materials for bioartificial grafts.

REFERENCES:
1) Brink, M. F., M. D. Bishop, and F. R. Pieper. 2000. Developing efficient strategies for the generation of transgenic cattle which produce biopharmaceuticals in milk. Theriogenology 53, 139-48.
2) Butler, D. L., and H. A. Awad. 1999. Perspectives on cell and collagen composites for tendon repair. Clin. Orthop. 367, S324-32.
3) Currie, L. J., J. R. Sharpe, and R. Martin. 2001. The use of fibrin glue in skin grafts and tissue-engineered skin replacements: a review. Plast. Reconstr. Surg. 108, 1713-26.
4) Desai, U. A., G. Sur, S. Daunert, R. Babbit, and Q. Li. 2002. Expression and affinity purification of recombinant proteins from plants. Protein Expr. Purif. 25, 195-202.
5) Fernandez-Otero, T. 2000. Biomimicking materials with smart polymers. IN Structural Biological Materials,M. Elices, Ed., Pergamon. Pp. 187-220.
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8) Hinman, M. B., J. A. Jones, and R. V. Lewis. 2000. Synthetic spider silk: a modular fiber. Trends Biotechnol. 18, 374-9.
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10) Lazaris, A., S. Arcidiacono, Y. Huang, J-F. Zhou, F. Duguay, N. Chretien, E. A. Welsh, J. W. Soares, and C. N. Karatzas. 2002. Spider silk fibers spun from soluble recombinant silk produced in mammalian cells. Science, 295, 472-6.
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12) Surrey, T., F. Nedelec, S. Leibler, and E. Karsenti. 2001. Physical properties determining self-organization of motors and microtubules. Science, 292, 1167-71.

KEYWORDS: biomaterials, protein production

A03-055 TITLE: <u>Cross-Layer Wireless Networking for Low Energy Sensor Networks</u>

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: The purpose of this SBIR is to develop an integrated cross layer wireless network protocol suite for low power, low duty cycle sensor radios.

DESCRIPTION: One component of the Army's Future Combat System (FCS) will be networks of sensors, with finite energy capacity and extended lifetime. For more detail on the vision this sensor web, see [1]. There will be a large number of low cost simple sensors (acoustic, seismic etc.), for which the data will need to be aggregated, compressed, and fused. Normally, there will be very little data required to be communicated between the sensors. However, when one sensor detects an event, many sensors will detect the same event and there will be a sudden flurry of activity in the network. The networking protocol should be independent of the sensor type, but should be optimized for small data packets such as from an acoustic, magnetic, or seismic sensor as opposed to the large bandwidths required for images (video, IR, radar, etc.).

Conventional IP networking is highly inefficient and unnecessary for the sensor network; however, the sensor network must be able to interface with an Internet Protocol (IP) network. There may be some, but many fewer, more capable gateways within the network, able to assist with data fusion and the IP network interface. Similarly, TCP has been found to be inefficient in ad hoc networks and will be even worse in sensor networks. Therefore alternatives to TCP at the transport layer are required, with the possibility of some of the functionality being moved into the lower protocol layers. Routing protocols have been developed for ad hoc networks, but need to be revisited under the very low energy requirements of sensor networks. Also, medium access control and link layer protocols can be optimized under the sensor network paradigm. Although not a main objective of the program, some assumptions on the physical layer design must be made. (Two possible physical radios are described in [1] and [2].)

Therefore a complete protocol suite is required from the data link layer to the transport layer. These protocols should be designed in a true cross layer manner, optimized to the specific application of the sensor web. In order to further reduce power, after network initialization, packets required for synchronization and net maintenance should be minimized or eliminated.

PHASE I: Research, development, and trade-off analysis of cross layer networking protocol design for very low energy sensor network. Develop simulation tools to evaluate the various approaches. Perform the analysis and simulation of the proposed protocols and provide the results in a report. This report will also include a summary of potential commercial applications and the projected benefits from the use of this technology that could form the basis of commercial business opportunities.

PHASE II: Further develop the most promising design from Phase I. Use the results to implement cross layer networking software for a target sensor radio. Demonstrate a moderately sized sensor network with simulated sensor data. In addition to the software, a useable protocol specification will be produced.

PHASE III DUAL USE APPLICATIONS: Refine the software and interfaces to be useable for commercial as well as DoD applications. Suggested non-DoD applications: Sensor networks for homeland defense of critical infrastructure and other security related applications.

REFERENCES:
1) J. Gowens and J. Eike, "Networked Sensors: Armor for the Future Force", Proceedings of 2001 SPIE AeroSense Conference, vol. 4396, pp. 1-7.
2) http://robotics.eecs.berkeley.edu/~pister/SmartDust/.

KEYWORDS: Sensor networks, communications protocols, cross layer design

A03-056 TITLE: Man Portable Personnel Detection Device for MOUT

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM NV/RSTA

OBJECTIVE: To design, build and test a man-portable sensor or sensor system that will enable a team of soldiers to rapidly determine the presence of individuals in a room, suite, or an entire building from the outside with minimal risk to the team.

DESCRIPTION: In military operations on urbanized terrain (MOUT), teams of soldiers need to secure buildings by rapidly moving through the hallways and determining the presence and location of occupants, if any. A man-portable device or devices is sought that can determine the occupation of the room within a few seconds and before entry. A single, man-portable sensor would be ideal, however, multiple man-portable sensors would be acceptable if they were not too cumbersome and did not decrease team survivability. Also acceptable would be the use of an external device outside the building, either by itself or in conjunction with sensors inside the building. Possible sensor technologies include, but are not limited to, acoustic, olfactory, millimeter-wave imaging, RF/radar or combination thereof. It is envisioned that acoustic technology may be able to detect the human function of a heartbeat or respiration, although there is a severe problem with background noise and false alarms. Olfactory sensing would have to detect through the walls, or, possibly, be slipped under the door. Millimeter-wave, radar or RF sensors can see through walls and may be able to detect a heartbeat or breath, although resolution and portability are challenges. Signal processing that takes advantage of periodic events may be useful for sensors that monitor heartbeats or respiration. The room occupant(s) may not be moving, which reduces the value of large-scale motion detection as the primary detection mechanism. In addition, more than one occupant may be present and multiple signals should not confuse the decision process. Note that the device would have to distinguish team members outside the room from the room occupant(s). The final device will, more than likely, combine two or more different technologies and multi-sensor data fusion should be developed to produce synergies among the selected sensors. Since different physical phenomena are involved it is expected that sensor independence would increase the probability of detection and mitigate false alarms.

PHASE I: Demonstrate a prototype sensor or sensor mix and algorithms that can determine the occupation status of a room from the outside, or with minimal intrusion that does not put the soldier in harms way. The rooms may consist of different construction, ranging from drywall or plaster to concrete. Using reasonable assumptions, determine expected probability of detection versus false alarms for an optimized system in both calm situations and battlefield operation. Identify path for improvements to meet conditions of man-portability, rapid time response, and battlefield operation.

PHASE II: Assemble and test an optimized sensor suite and display/readout that is man-portable and has a high probability of detection with low false alarms. Identify different system configurations for different building construction, if possible. At end of Phase II, prototype system should be available for testing by DOD personnel in urbanized terrain.

PHASE III DUAL-USE APPLICATIONS: Follow-on activities are expected to be aggressively pursued by the offeror and involve development of ruggedized and robust devices for actual use by military personnel. Different sensor suites may be developed to allow for changing construction and different battlefield scenarios. Civilian police and private security personnel would find this device useful to determine if a room was occupied before entry. This may also enable firefighters to locate unconscious people in burning or smoke filled rooms.

OPERATING AND SUPPORT (O&S) COST REDUCTION (OSCR): The key advantage of such a sensor system is that it would take the soldier out of harm's way in the restricted confines of urban terrain. This will improve survivability and yield a corresponding force multiplication effect by enabling faster and safer operations in urban terrain.

REFERENCES:
1) Detection and Identification of Visually Obscured Targets, C. E. Baum, (ed.), Taylor and Francis, 1999.
2) G. Grenaker, "Radar sensing of heartbeat and respiration at a distance with security applications," Proc. SPIE, Radar Sensor Technology III, V. 3066, 1997, p22-27.

KEYWORDS: MOUT, personnel detection

A03-057 TITLE: High Power, High Efficiency Diode Sources for Pumping Eye-Safe Solid State Lasers

TECHNOLOGY AREAS: Materials/Processes, Sensors

OBJECTIVE: To develop and fabricate high power, high efficiency diode sources for efficient resonant pumping of eye-safe, erbium-doped, solid-state lasers.

DESCRIPTION: High gain, high energy solid state lasers that operate in the eye safe region (wavelength > 1.5 microns) are in demand for military and commercial applications. These lasers, which are based on crystals doped with erbium (Er) atoms, are expected to be more compact and efficient than currently available lasers obtained with frequency conversion from shorter wavelengths. There are several military requirements for such lasers. One is the augmentation of fire control systems with the capability to identify the target (Target ID) using 3D laser radar (LADAR) imaging techniques. Another is the development of ultra-high power lasers for improved missile defense systems. Commercial applications of eye safe lasers include the development of free space communication nodes of conventional fiber optic networks and laser cutting/welding systems for manufacturing.

Eye-safe solid-state lasers are based on Er-doped crystals which have a number of absorption bands located from the visible to the near infrared spectral regions. Presently, such lasers are pumped by semiconductor diode sources operating at ~ 0.98 microns. Since the eye-safe lasers operate at ~ 1.5 microns, the difference in energy between pump beam and laser emission gives rise to heat within the laser medium. Thermal management becomes a critical issue in developing high power, eye-safe solid-state lasers. Diode sources operating within the spectral ranges of either 1.47-1.48 and 1.53-1.54 microns would provide much more efficient pumping of the Er-doped crystals. This would lead to higher energy, higher gain operation with minimal energy loss to the host medium. Such diode lasers are not commercially available at present. A compact, high efficiency diode semiconductor source capable of delivering high energy pulses near 1.5 microns to Er-doped crystals needs to be developed. This will require precise control of the material composition and the electronic properties of semiconductor materials used in such diodes. Low cost, reliable fabrication methods need to be developed for such laser diodes. Appropriate collimating optics must also be developed to deliver a high brightness pump beam to the Er-doped laser crystal. Careful thermal design of the array package is also required to maintain the laser diode source within the pump wavelength band for pulse lengths of at least 5 milliseconds.

PHASE I: Perform a feasibility study through modeling and simulation of a compact diode source appropriate for maximum power operation in the regions of 1.47-1.48 or 1.53-1.54 microns. Assess the feasibility of a manufacturing process for diode fabrication including packaging and collimating optics.

PHASE II: Develop and fabricate prototype high power compact diode sources for resonant pumping of eye-safe Er-doped Q-switched lasers.

PHASE III DUAL USE APPLICATIONS: The high power compact diode source will have applications in both commercial and military markets. Compact, high efficiency sources operating in the eye-safe spectra region are required for solid state laser pumping, for illuminators in night vision imaging systems, and for laser welding/cutting systems.

REFERENCES:

1. S. D. Setzler, P. A. Budni, and E.P. Chicklis, “A High Energy Q-switched Erbium Laser at 1.62 microns,” OSA Trends in Optics and Photonics Vol. 50, Advanced Solid-State Lasers, Christopher Marshall, ed. (Optical Society of America, Washington, DC 2001), pp. 309-311.
2. E. Chicklis, S. Setzler “Eyesafe Q-switch laser”, US patent application 09/841,727, filed 04/26/2001. Pub. No.: US 2001/0036205 A1.
3. G. Belenky, L. Shterengas, C. W. Trussell, C. L. Reynolds, Jr., M. S. Hybertsen, R. Menna, “Trends in semiconductor laser design: Balance between leakage, gain and loss in InGaAsP/InP MQW structures” in “Future Trends in Microelectronics: The Nano Millennium" (2002), Wiley ISBN: 0-471-21247-4, p. 231.


KEYWORDS: Eye-safe lasers, Diode sources, Erbium-doped crystals, Laser radar systems

A03-058 TITLE: Chaotic Radio Frequency (RF) Sources for Ranging and Detection (RADAR) Applications

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Design methods of efficiently generating chaotic radio frequency signals for ranging and detection applications and develop a prototype system.

DESCRIPTION: Technical Challenge/Background: Chaotic sources offer a new model for designing versatile, wide bandwidth RF sources for communications and radar applications. As opposed to conventional signal generation approaches that require explicit modulation of rock-stable oscillators, inherently unstable oscillators may offer more flexibility while operating in regimes of better efficiency. The wideband, non-repeating nature of chaotic waveforms makes them ideal for high-accuracy unambiguous ranging with high resistance to jamming as well as low probability of detection. In addition, the deterministic nature of chaos allows auto-synchronization between transmitter-receiver pairs. Exploiting these properties in a complete system is an unexplored arena.

PHASE I: Identify sources of RF chaos that are readily modeled and have potential to be used in ranging and detection systems. It is reasonable to expect that traveling wave tubes (TWT), klystrons, or other standard RF sources may be coaxed into generating chaotic output. The source must exhibit a broadband waveform due to deterministic dynamics, which can be modeled to facilitate controller design and predict performance characteristics. Preference will be given to sources that have regimes of low-dimensional chaos for which a symbolic dynamical description exists. The first phase of this project is intended to be solely theoretical. Brainstorming of commercial application possibilities and potential benefits that might form the basis of future commercial business should be carried out in this phase.

PHASE II: Develop and demonstrate a prototype system using the most promising chaotic RF source identified in Phase I. Carry out experimental studies of transmission, reception, control, and synchronization in realistic environments by simulation and by physical experiments in a laboratory environment. Identify limitations on the prototype system and on potential follow-on systems. Characterize the level of accuracy/confidence in the system within those limitations.

PHASE III: All listed benefits to military applications also apply to commercial uses. The potential low-cost nature of this technology makes it particularly applicable for civilian uses such as automotive collision avoidance systems.

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1) Mathematical and Computer Sciences Division, Toward a New Digital Communication Technology Based on Nonlinear Dynamics and Chaos, Army Research Office, Research Triangle Park, North Carolina, 1996.
2) A. S. Dimitriev, A. I. Panas, S. O. Starkov, and B. E. Kyarginsky, "Direct chaotic circuits for communications in microwave band", Radiotekhnika i elektronika, 2001, Vol. 46, pp. 224-233 (in Russian), nlin-cd/0110047 (English).

KEYWORDS: Chaos, radar, wide bandwidth

A03-059 TITLE: Compact Submillimeter-Wave Sources and Detectors for Biological and Chemical Spectroscopy

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To design, build and test compact, all-solid-state sources and detectors capable of full waveguide band spectroscopy in the submillimeter-wave frequency band. The envisioned system should be developed such that it is deployable as a portable gas and/or biosample analyzer and be suitable for extension to both a stationary perimeter defense system and an outward-looking remote scanning system.

DESCRIPTION: The present capability for point-detection of biological (bio) agents is limited to the identification of only four species [1]. This limitation in point-detection and the limitations of an effective standoff (i.e., remote) capability is of the highest priority to the Joint Future Operation Capability, as well as to the Joint Service Leader for Contamination Avoidance and most importantly to the DoD. When these general problems are combined with the need to realize a compact (i.e., very small size and weight) total CB systems package for the FCS concept, it is obvious that new approaches will be necessary.

The field of chemical spectroscopy has long used the submillimeter-wave portion of the spectrum to detect and identify trace gases [2]. In fact, catalogs of thousands of molecular gas spectra are now available. More recent work has shown that biomacromolecules also have unique spectra in this frequency band. However, in this case the absorption lines are due to phonon modes in the longer molecular structures. Recent scientific work in biological spectroscopy at very high frequencies has suggested a novel avenue for a terahertz (THz) electronic approach to bio-warfare agent detection and identification [2]. These studies support previous theoretical analysis that predicted unique resonant-phonon absorption features within the basic components (i.e., DNA) of biological materials [3]. However, even the most compact and affordable spectroscopy tools available in this frequency band today rely on large, expensive and unreliable tube sources, such as Backward Wave Oscillators, and cryogenically cooled detectors. Such systems, although useful for basic laboratory research, are unsuitable for large scale deployment in airports or military applications. The proposed effort would replace the tube based sources and cryogenic detectors with all solid-state components that are compact, reliable and affordable for large scale implementation. The expected system should possess a capability for effective operation (e.g., high frequency resolution and broadly tunable) throughout the THz frequency band. The system should leverage fully-integratable semiconductor-based components to enable the realization of a compact and cost-effective sensing system. The system should be tested to demonstrate the sensitivity limits and discrimination capability. Finally, the system should be developed such that it is amenable to battlefield deployment type scenarios.

PHASE I: Conduct a comprehensive analysis and design phase for a semiconductor-based THz sources and detectors for frequency domain spectroscopic system. Source power levels in excess of one milliwatt over complete waveguide bands should be achieved. Detector sensitivities (NEP) of order 10-12 to 10-13 WHz-1/2 should be demonstrated. The system must operate at room temperature and should consume less than 25W. This work should include the demonstration of the source and detector components in the submillimeter-wave band (>300 GHz), design of a complete spectroscopy system and evaluation of the scalability of the system throughout the 0.3 – 3 THz frequency band.

PHASE II: Develop and demonstrate a prototype submillimeter-wave direct frequency spectrometer for the analysis of biological and chemical samples. The source system should be compact and rely on solid-state components and have a high level of integration. The room temperature detector must yield sufficient sensitivity to replace cryogenic detectors. The source and detector must cover complete waveguide bands yet have no mechanical tuning elements. The complete system must be scalable to at least 1 THz and prototype sources and detectors for 1 THz must be demonstrated.

PHASE III DUAL USE COMMERCIALIZATION: The technologies developed under this topic will provide a foundation for a new class of spectroscopy systems for remote sensors, airport screening of explosives, detection of chemical laboratories, medical diagnostics, monitoring of biocontaminants in food processing plants and as a laboratory tool for the microscopic interrogation of biological characteristics and chemical function. This spectroscopic technique also has potential towards the characterization of other materials of interest such as electronic materials.

REFERENCES:
1) D. Woolard, "Terahertz Electronics Research for Defense: Novel Technology and Science," in the proceedings to the 2000 Space THz Conference, U. of Michigan (2000).
2) F. C. De Lucia, "THz Spectroscopy – Techniques and Applications," 2002 IEEE MTT-S Symposium Digest, Seattle, WA. June 2002.
3) D. Woolard, et. al., "Terahertz Electronics for Chemical and Biological Warfare Agent Detection," in the proceedings to the 1999 IMS, June 13-19, Anaheim, CA., pp. 668-672 (1999).
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5) D. Woolard, et. al., "Sensitivity Limits & Discrimination Capability of THz Transmission Spectroscopy as a Technique for Biological Agent Detection," in the proceedings to the 5th Joint Conference on Standoff Detection for Chemical and Biological Defense, Williamsburg, VA., 24-28 Sept., 2001.

KEYWORDS: Terahertz frequency sensors, biological agent detection, remote sensing

A03-060 TITLE: Personnel Detection and Warning Systems for Perimeter, Ambush, and Casualty Detection.

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To identify sensor modalities and develop technologies for detecting and locating the presence of humans for perimeter protection, ambush warning, and casualty detection.

DESCRIPTION: Concepts of the future Objective Force call for high mobility of the warfighter in the battlespace. An impediment to mobility and security is uncertainty about the presence and location of enemy warfighters. The use of dogs to warn warfighters of the presence of enemy has been very successful in improving the mobility and security of patrols. A sensor system which can detect humans and provide direction and range would provide increased protection for the warfighter enabling higher mobility. Such a system would be used to detect and locate, e.g., snipers and ambushers. Medics could use the system to find casualties. The use by guards and sentries would enhance perimeter and physical security, since sensor systems could be deployed around the perimeter of installations and facilities to detect intruders. The identification of a suite of sensing modalities is an objective of this research. The system needs to be energy efficient, lightweight, small, and robust and must have a low false alarm rate in the presence of animals such as deer and rabbits. Sensors will need to be trained not to alarm on the operating personnel carrying the sensor. An approach using passive sensors, such as infrared, acoustic, and olfactory, would provide a much higher degree of protection than active sensors, such as radar, since passive sensors do not provide a detectable signature that would alert the enemy or intruder. The sensor suite may also include chemical detectors to detect materials carried by humans or soldiers, such as explosives or cigarette smoak. Other possible sensor modalities are heartbeat and breathing sensors, hyperspectral imaging, polarization imaging, low-energy x-ray, terahertz chemical sensors, and millimeter wave radar. However, the latter sensors are active and not passive. A multimodal approach will require the use of sensor fusion. The method of alerting the warfighter to the presence, direction, and range of humans should be quiet and undetectable to enemy warfighters in the area. The man-portable system must operate from batteries and be highly energy efficient providing about three days continuous operation. This topic does not include recognition of human faces, gestures, and motions - only the detection of the presence, direction, and range of humans.

PHASE I: Conduct feasibility study and analysis and propose sensor suite and preliminary design concept.

PHASE II: Develop hardware and software for a demonstration in realistic outdoor environments.

PHASE III DUAL USE COMMERCIALIZATION POTENTIAL: Develop a prototype system for the Army warfighter which can also be used by civilian physical security personnel both indoors and outdoors.

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KEYWORDS: Intruder detection, human detection, human identification, sensor fusion

A03-061 TITLE: Integrated Computational Algorithms to Treat Fracture and Fragmentation

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop advanced and innovative numerical algorithms to describe discontinuities or moving boundaries and their complex interactions under blast and penetration loading conditions. The algorithm should be able to describe geometrically and materially nonlinear problems by alleviating the difficulty of meshing and remeshing, and numerical instability due to large deformation, shock propagation, and localized failures.

DESCRIPTION: During the past three decades, several computational codes based on finite element discretization have been successfully developed to solve structural problems under quasi-static and vibration loading conditions. However, most commercial finite element codes are incapable of describing the details of fracture and fragmentation of buildings and military vehicles due to blast and projectile penetration loadings under extreme dynamic pressures and elevated temperatures and also are limited to a certain class of problems.

Recently, several academicians proposed alternative methods to the finite element based algorithms. The proposed meshless methods are attractive alternates to Lagrangian/Eulerian and smooth hydrodynamic particle based algorithms/codes. There is an urgent need for the development of software based on meshless methods to describe fracture and fragmentation of three-dimensional structures and advanced armor/anti-armor systems. The software should include smooth and non-smooth contact algorithms, adaptive particle or node migration to capture steep gradients induced by localized shock and penetration, and elevated thermal loading conditions. In addition, thermodynamically consistent and mechanics based material models capable of describing material responses under high pressures, high strain rate, and high temperatures should become part of the software system. The code development requirements include the integration of several nonlinear mathematical methods for describing highly nonlinear physical phenomena associated with the dynamic response of solids and structures.

Because of the aggressive schedule for technology insertion into the Future Combat Systems for the Objective Force, there is an urgent need for the development of efficient and accurate computational codes to describe fracture and fragmentation of structures and systems under survivability design analyses. The resulting technology will allow rapid virtual prototyping and enable significant reduction in the design cycle time of armor and anti-armors for ultra lightweight systems.

PHASE I: Select a candidate meshless algorithm and develop a three-dimensional code based on that algorithm. Validate the code through simulations of static and dynamic problems for which analytical and other numerical solutions exist.

PHASE II: Produce fully integrated software to model and simulate moving boundaries and discontinuities under multiaxial loading conditions. The code should also include thermodynamically consistent and mechanics based advanced material and equation of state models capable of describing material responses under high pressures, high strain rate, and high temperatures. Develop a MPI based version of the software that will run in massively parallel computers. Validate the MPI based three-dimensional code through simulating sample blast and penetration problems for which experimental measurements (high-speed photographs and in situ measurements of surface velocity and stresses inside the solids) are available. Develop appropriate pre- and post processors suitable for setting up the code and analyzing the results from the MPI based code, respectively.

PHASE III DUAL USE APPLICATIONS: Develop the prototype meshless code from Phase II into a robust and scalable virtual simulation facility or product with Graphical User Interface (GUI) for integrated pre- and post-processors appropriate for the commercial and military market.

OPERATING AND SUPPORT (O&S) COST REDUCTION (OSCR): Traditionally, a major part of the resources in-terms of time and cost is spent to setup the highly complex three dimensional structures and systems through complicated meshing and remeshing. In addition, a fairly a large amount of time is spent in global/local analyses of fracture and fragmentation through the post-processing of large amount of data. Simplification of the modeling and simulation through a GUI based software system that uses a meshless approach will reduce the engineering costs of future commercial and military survivable systems.

REFERENCE:

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KEYWORDS: modeling and simulation, survivability

A03-062 TITLE: Integrated Information Interface for Electromagnetic Modeling and Simulation Tools

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO C4IEWS

OBJECTIVE: Create a Graphical User Interface (GUI) with integrated pre- and post-processors that interface with efficient and accurate computational electromagnetics engines to allow rapid virtual prototyping of communication and radar systems and antennas for the Objective Force.

DESCRIPTION: Electromagnetic modeling and simulation engines are indispensable tools for communication and radar system development, as well as mission planning. Recent research in algorithms and implementation has produced efficient and accurate codes for full-wave electromagnetic analysis with CPU and memory requirements reduced by orders of magnitude. However, these codes tend to require complex input data files and produce large output data files that can be difficult to interpret. These requirements increase the design cycle time and reduce the allowable complexity of the problem under analysis.

Because of the aggressive schedule for technology insertion into the Future Combat Systems for the Objective Force, the user interface to these efficient and accurate computational codes must be streamlined. This topic requires a GUI with integrated pre- and post-processors that gives the operator an efficient means to set up modeling and simulation problems and scenarios, and provides a vehicle for visualization and intuitive interpretation of the simulation output data. The GUI should work with existing electromagnetics engines and be scalable and robust enough for commercial and military users.

The resulting technology will allow rapid virtual prototyping and enable significant reduction in the design cycle time of communication and radar systems and antennas for the Objective Force.

PHASE I: Select one or more candidate electromagnetic computing engines and determine input and output data exchange requirements. Develop initial concept design for and identify key elements of a GUI with integrated pre- and post-processors to generate input data and display output data for the candidate electromagnetic computing engines. Determine technical feasibility of integrating the proposed GUI with the selected computational engines.

PHASE II: Develop prototype GUI code and demonstrate the capability to generate input data and display output data with the selected computational engines. Demonstrate the capability to set up, analyze, and display a simple electromagnetics problem such as a dipole antenna radiation pattern or the radar cross-section of a canonical object and validate the simulation results using experimental data or analytical results.

PHASE III DUAL-USE APPLICATIONS: Produce a fully integrated GUI supporting one or more selected electromagnetic computing engines using the prototype GUI code from Phase II. Provide code to DoD laboratories for evaluation and testing. Demonstrate the capability to set up, analyze, and display results from a complex electromagnetics problem with military relevance or commercial application.

OPERATING AND SUPPORT (O&S) COST REDUCTION (OSCR): Simplification of the modeling and simulation interface will reduce the engineering costs of future commercial and military communications and radar systems.

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KEYWORDS: GUI, modeling and simulation, electromagnetics

A03-063 TITLE: Remote Neurological Measurement and Sensing

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Future Combat Systems

OBJECTIVE: Develop methods to remotely, and unobtrusively, collect, transmit and/or store neurological data from warfighters in an operationally realistic environment.

DESCRIPTION: Information is the key enabler of the Objective Force. There is a subtle, but critical, difference between information superiority and decision superiority. It is dependant upon understanding – the ability to comprehend and project information. When this is effectively coupled with training and experience it becomes wisdom, and wisdom is a critical enabler for reducing cognitive workload and expediting decisions using case-based reasoning. The disparity between information superiority and decision superiority amounts to human cognition--the ability of operators to synthesize, analyze, and act on information available. A key to achieving decision superiority is the optimization of human-system interfaces that facilitate maximum situational awareness for a given amount of information.

To date, a major obstacle in achieving this optimization has been the dearth of tools and methodologies available to objectively measure human cognitive performance. Without objective measures, all too often expediency becomes the driving force in design and implementation of human interfaces. Methodologies and metrics have been/are being developed to provide an objective analysis, given the proper inputs. Critical to the success of these assessments is objective measures of stress, workload, cognitive state, etc.

Therefore, to aid in these objective tests and assessments, it is necessary to remotely collect physiological and neurological data from test participants ('remote' in the context of a test environment is defined as the ability to capture test data in an environment where the data acquisition system is located at some prescribed standoff distance from the test instrumentation, and is connected either via wireless or standard fiber connection). To ensure operational realism and relevancy, these tests are, by nature, in high stress, high impact, environments. As such, the required instrumentation must be lightweight, robust, and must be capable of being integrated into existing test and operational systems.

PHASE I: There are a wide variety of physiological and neurological parameters that can be measured and assessed. The focus of Phase I shall be the determination of the most critical neurological parameters to be measured to assist in the determination of stress, workload and cognitive state. Included in this determination shall be a trade study on the most appropriate, and best suited, method for measuring these parameters in the stated environment.

PHASE II: Prototype hardware and/or software should be developed to demonstrate the ability to collect, transmit and/or store neurological data in an operationally realistic environment. Demonstrations (laboratory and/or field experiments) shall be conducted to demonstrate the efficacy of the prototype system(s). The contractor shall also begin the process of mapping neurological responses to individual learning and working styles, situational awareness development, and assess possible shifts in situational awareness in conditions of high workload and stress.

PHASE III DUAL USE COMMERCIALIZATION: The proposed technology will have a high payoff throughout DoD, not only to Research, Development, Test and Evaluation (RDT&E) activities, but to operational elements as well. The proposed instrumentation will be applicable to any warfighter on any platform – dismounted warrior, pilots/aircrews, sailors, UAV/UGV operators, etc. Projected uses beyond RDT&E include warfighter physiological status monitoring, combat casualty care & telemedicine, training and personnel selection. Potential commercial medical applications include use by Emergency Medical Services (EMS), in-home monitoring of patients to reduce hospital stays, and to support research into developing cures for neurological disorders such as Parkinson's Disease, epilepsy, Alzheimer's, etc. These systems would also be of high value to the commercial sector in the design, development and RDT&E of commercial aviation systems, long-haul trucking – essentially any system requiring a human-machine interface, particularly in high stress, high workload environments.

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KEYWORDS: neurological, physiological, cognition, performance, decision, perception, memory, man-machine interface, human systems integration

A03-064 TITLE: Advanced Electro-Optical/InfraRed (EO/IR) Projector for Testing Imaging Sensors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO Simulation, Training and Instrumentation

OBJECTIVE: Development of an advanced electro-optical/infrared (EO/IR) projector for simultaneous testing of multi-band sensor suites (containing visible sensor, Mid-Wave Infrared (IR) Forward Looking IR (FLIR) and Long-Wave IR FLIR). Complex scenes projected by the advanced EO/IR projector must have a large temperature range, high spatial resolution, high temperature resolution, and a highly correlated multi-band spectral output. The projector should be capable of testing both scanning and staring sensors. The spatial and temporal resolution should be sufficient to support testing of current and next generation visible and IR sensor/systems. The temperature/amplitude resolution should exceed the temperature resolution of these systems. It is also desired that the projector system be designed for mobile test applications and support testing of systems with sensor fusion algorithms. Such technology would be applicable to many commercial uses involving the development and testing of commercial visible and IR sensors used in homeland security, medical imaging, police/fire detection systems, collision avoidance systems and other property protection systems.

DESCRIPTION: One potential candidate projector technology for this application is the large format resistor array projector system. However, this technology alone can not support testing of sensors operating within the visible-spectrum since the spectral output is only suitable for sensors operating within the infrared-spectrum. These resistor array systems also suffer from other limitations including: limited spatial resolution (currently 512x512), spatial non-uniformity, dead pixels, limited frame rate, heat dissipation problems, and limited availability (relatively high cost).

Another potential candidate projector technology for this application is the micromirror array projector system. However, this technology is currently limited in application to staring (non-scanning) sensors and seekers due to the inherent reliance on pulse width modulation for the generation of intensity levels. It is also limited in amplitude resolution and contrast in the LWIR band.

An innovative approach is needed to overcome the limitations of these currently available projector technologies. The advanced EO/IR projector system developed under this effort should meet the following performance goals:
· Spatial resolution/format: > or = 1024x1820
· Spectral waveband: 0.4-14 um (visible to LWIR)
· Amplitude resolution: > or = 14 bits
· Maximum Apparent Temperature: > or = 100° C
· Minimum Apparent Temperature: < or = 0° C
· Instantaneous Pixel to Pixel Delta Temperature: > or = 100° C
· Variable Dynamic Range Control
· Flickerless
· Mobility is desired

PHASE I: Perform a feasibility study of the development of an advanced EO/IR projector system which meets the specifications above. Evaluate innovative technologies which may be used to build and integrate the advanced EO/IR projector system and leverage existing projector technologies. Perform trade-off analysis to determine the best approach for each subsystem, and develop a preliminary design for the advanced EO/IR projector system. Perform modeling and analysis to establish the proof-of-principle and predict the performance specifications for the final system.

PHASE II: Develop a prototype advanced EO/IR projector system. Demonstrate the advanced projector technology and characterize its performance.

PHASE III DUAL USE APPLICATIONS: The advanced IR projector developed under this topic would provide an excellent test bed to support the development and testing of imaging EO/IR sensors used in both ground and aviation military platforms. The system could also be applicable to medical imaging, police surveillance, fire prevention/detection, auto collision avoidance systems and intrusion detection systems. Commercial applications for this technology might be found in the medical, law enforcement, fire, automobile, home security, and aircraft industries.

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KEYWORDS: Infrared, projector, sensor fusion, electro-optical, simulations

A03-065 TITLE: Variable Cold-Stop for a Multi-Band Infrared Imagers

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The objective is to develop a variable cold-stop that will interface to an existing infrared camera in the mid-infrared (3um-5um) spectrum. The investigator will demonstrate the feasibility of the variable cold-stop by manually adjusting the cold-stop to match the infrared lense from different manufacturers. The investigator will determine the best cooling technology and material available for the cold-stop. The investigator will consider materials such as Silicon, Germanium, Sapphire, zinc or other compatible materials. The infrared camera?s desirable features are an RS-170 video port to demonstrate adjustment of the variable cold-stop and a high-speed digital data port (12-16 pixel format) to save the data. Minimum resolution shall be on the order of 640 x 512, desired minimum frame rate/second shall be 100 to 300. Additional desirable features are simultaneous frame shuttering, minimized blooming, low fixed pattern noise, high sensitivity, windowing, horizontal and vertical binning for higher frame rates, and very low power consumption. The investigator will provide the best solution design for an adjustable cold-stop that will accommodate f-4 to f-10 lenses with a standard f-mount interface, or a common industry standard lens mount.

DESCRIPTION: Infrared imagers have been designed with cold-stops that limit the use of infrared lenses from different manufacturers. To realize the objective of this effort, it is anticipated that a deviation from the traditional wavelength imager and cold-stop matching , to a more versatile architecture design will be required. The cold-stop is a field of view (FOV) limiting aperture, and is cryogenically cooled to block unwanted background radiation from reaching the detector. The investigator shall determine the best solution for eliminating unwanted background radiation from reaching the detector when adjusting the cold-stop for different focal length lenses.

PHASE I: The investigator shall conduct the necessary analysis and research to develop a cold-stop for an existing infrared camera in the (3um to 5um) spectral range. Resolution will be a minimum of 640 x 512 and the desired frames/second will be 100 to 300 with a 12-16-bit pixel format. The variable cold-stop will be developed to accommodate lenses from f-4 to f-10. The analysis and research shall provide the basis for a full-scale prototype variable cold-stop integrated into an existing infrared camera development in Phase II. Technical risk is to be minimized by leveraging from existing technology.

PHASE II: The investigator shall proceed with prototype development and demonstration of the technology proposed in Phase I. The full-scale prototype variable cold-stop integrated into an existing infrared camera shall ensure that other issues beyond the sensor are addressed. These issues include, but are not limited to, high-speed digital data interface, time stamping of individual frames, alternative infrared lens mounts, and a data storage solution.

PHASE III: APPLICATIONS include Test and Evaluation Ranges, military and commercialization. Potentially there is a tremendous worldwide application for variable cold-stop infrared imagers that will find wide spread use in the medical field, law enforcement, industrial inspection systems, search and rescue, military and aviation.

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KEYWORDS: Infrared, Cold-Stop, Digital Cameras, Interchangeable Infrared lens, Sensor, Focal Plane Array, Silicon Germanium (SiGe), Material

A03-066 TITLE: Airspace Management and Deconfliction of Networked UAV

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop an airspace management system that operates on a small UAV level that deconflicts multiple small UAV in real time using limited sensors, communications, and processing. The system will be able to monitor networked UAVs, deconcflict their airspace, and when necessary enable redirecting multiple networked UAVs simultaneously in support of UAVs Operations controlled from mounted and dismounted forces.

DESCRIPTION: With the proliferation of UAV in the future battlefield associated with FCS and the objective force, the skies above the future battlefield will be very crowded. Future forces face an increasingly difficult task of managing UAV assets while making sure they don't bump into each other or into manned aircraft or get in the way of direct and indirect fires. Small UAVs especially, pose a significant challenge in that their size and sensor payload restrictions limit their onboard capability, which in turn puts increased importance on external airspace management.

This effort will focus on Decision Aiding to help deconflict and manage level all Small UAVs (OAV and MAV size) under a Ground Commander’s direct control and with all known Air Vehicles (manned or unmanned) and artillery operating in the same airspace. As an example, the system should try to project UAV paths, predict potential collisions, and suggest realistic flight path modifications to avoid the collision. The UAV management system must be network aware and use a combination of push and pull technologies to disseminate the required information while minimizing overall network bandwidth. Both centralized and distributed solutions to the airspace management should be investigated. As a goal, the software should be scalable and portable to permit operation on a variety of platforms. This effort should focus on an area typical of an FCS Combined Arms Battalion’s operations. This system should facilitate coordination over communication and UAV control networks of an overall airspace management strategy among UAV operators, multiple air management systems, and the UAVs themselves.

PHASE I: Conduct trade study to identify best methods and technologies for conducting SUAV Airspace management and deconfliction in a FCS Combined Arms Battalion like environment. Develop a proof of concept the some of the key components for the SUAV Airspace Management System identified in the trade study.

PHASE II: Develop a prototype demonstration of the technology of interest for SUAV Airspace Management and Deconfliction System in simulation. Demonstrate and evaluate the system in constructive simulation and live simulation.

PHASE III COMMERCIAL APPLICATION: This product has a very big potential for application to Operations in FCS and Objective Force. In DoD and commercial world this technology has potential for very broad application in many different venues. This system would be directly applicable to police, border and facility security surveillance, for search and rescue, and homeland security.

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KEYWORDS: airspace, management, deconfliction, decision aiding, UAV, SUAV, MAV, FCS, Battalion, collision

A03-067 TITLE: Active Trim Tab Actuator For In-Flight Rotor Blade Tracking

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Helicopter rotor blades must be tracked and balanced to eliminate the 1/rev vibration associated with dissimilar blades. The objective of this effort is to develop an actuator that can actively deflect a trim tab for in-flight blade tracking. Active trim tabs may allow for reduced aircraft downtime, lower operating and maintenance costs, and relaxed blade manufacturing tolerances. Active blade tracking will have potential applications to all manned and unmanned rotorcraft, both military and civilian.

DESCRIPTION: Research has been conducted over the past several years using shape memory alloys (SMAs) in the design of an active trim tab actuator. The development of the capability of precise positioning of an in-flight active trim actuator should lead to improved component lives, diminished vibrations, reduced maintenance, extended range, and better maneuverability.This effort should focus on developing a practical active trim tab actuator (whether they are SMAs or another smart material). Among the issues to be investigated are the actuator weight, required actuator power, trim tab control system complexity, and maximum trim tab deflection angle and deflection rate.

PHASE I: Effort in this phase should consist of the smart material selection and the active trim tab actuator design. "Proof of concept" testing of the actuator should also be conducted with attention focused on static and dynamic loading, torque limitations, locking requirements and mechanisms, and adequate response time, possibly regulated by position control electronics and cooling.

PHASE II: This phase should consist of active trim tab actuator refinement and extensive bench top testing. Analysis should be focused on predicting the performance levels of various actuator configurations, examining the effect of parameters on fatigue strength, blade weight, and balance. Actuator designs must be evaluated from the point of view of cost, reliability, and blade repairability. This phase should also contain the initial development of the active trim tab control system.

PHASE III: This phase should complete the trim tab control system development. Wind tunnel testing of the active trim tab system should be conducted to demonstrate the potential applications of in flight rotor tracking to rotorcraft, both military and commercial.

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KEYWORDS: helicopter vibration control, smart materials, shape memory alloys (SMAs), rotor blade tracking

A03-068 TITLE: Dismounted Small Unmanned Air Vehicle (SUAV) Associate

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop an Associate System to permit the Dismounted Warrior to control an SUAV through a PDA-like device integrated UAV controller so that he can perform his duties in an operational environment with minimal workload dedicated to UAV control. This associate system will permit the highest level of decision aiding and autonomy augmentation available given processor limitation to maximize hands free control and produce operationally relevant behaviors in an SUAV.

DESCRIPTION: One of the biggest challenges of future systems will be to team the Small UAV (MAV/OAV size) with dismounted forces. Limited processor and sensor capabilities severely restrict the level of autonomy of SUAVs, making management and utilization of them a challenge, especially for dismounted warfighters. Associate technology has the potential to provide the situational awareness and UAV management decision aiding to assist dismounted troops in maximizing their benefit. Since associate system technologies will likely require more processing capability than MAVs will have in the short term, the Dismounted SUAV Associate will have to operate within the Dismounted Warfighter's organic computing capability, and may have to be limited to execute in the organic, manpackable systems. The Dismounted SUAV Associate will therefore need to be capable of operating on MAV and OAV class sensor and state information over tactical data-links, and intelligent information flow between the SUAV and Associate must be carefully managed. In addition, because dismounted warfighter's computing devices vary, the Dismounted SUAV Associate must be constructed modularly to be capable of operating on a variety of processors, with multiple modalities, like voice recognition, HMDs, gestural controls, etc. The Dismounted SUAV Associate will bring associate system behaviors to the dismounted warfighter/ SUAV team, providing greater SUAV autonomy and increased human- SUAV collaboration. As a goal, the system should be able to handle UAVs with various levels of autonomy and degradation of the system, augment the autonomy of the SUAV, and provide a consistent interface and capability across a variety of UAVs. Operationally, the associate should be centered on the Future Combat Systems (FCS) Concept of Operations (CONOPS) and capabilities focusing on Urban Operations.

PHASE I: Based on future operational concepts such as FCS, conduct research and develop a spec for an Associate System to control an SUAV based on tactical, rugged PDA-like processing and GUI technologies available in 2006, assuming a 30% processor and memory utilization. Conduct research to determine what functionality is required operationally of the Associate software. Develop a preliminary design for a full Dismounted Associate based on the specification and functionality determination. Develop a plan for simulation and demonstration of the Dismounted SUAV Associate.

PHASE II: Develop the Dismounted SUAV Associate, test it in simulation to refine its functionality, and demonstrate the refined Associate using primarily COTS or existing developmental UAVs, controllers, and hardware.

PHASE III COMMERCIAL APPLICATION: This product has a very big application to dismounted Operations with FCS and Objective Force. In the DoD and commercial world, this technology has very broad application for many functions in which a human must interact with and control a robotic system in a "hands-free" "eyes-out" workspace. This system would be directly applicable to police, border and facility security surveillance, for search and rescue, and homeland security.

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KEYWORDS: Associate, decision aiding, UAV, SUAV, FCS, Distributed, robotic, autonomy, human-machine interface

A03-069 TITLE: Advanced Technologies for Improved Part Power Performance in Small Turbine Engines

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop and validate turbine engine technologies that are innovative, unique and offer significant performance payoff at part power.

DESCRIPTION: Advanced turboshaft engines are expected to be required to support future Army Uninhabited Air Vehicle (UAV)/Objective 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, particularly the UAV systems, is that excellent part power performance is required where significant time at cruise (part power) conditions is typically required and where time-on-station and range requirements will be stringent. The objective of this topic is the development and validation of turbine engine technologies that are innovative, unique and offer significant performance payoff at part power. Such technologies could include advanced flow control concepts, innovative cycle configurations, advanced clearance control concepts, or any other component technology that has potential to significantly improve part power performance aspects such as specific fuel consumption and/or surge margin. This will result in advanced objective force rotorcraft that can operate in a robust manner over a large power range for both cruise and full power conditions.

PHASE I: Establish the feasibility of proposed technology to improve part power performance aspects such as specific fuel consumption and/or surge margin 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 technologies for improved performance which will be applicable to both military and commercial gas turbine engine markets.

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KEYWORDS: Gas Turbine Engine, Turboshaft Engines, Part Power Performance, Uninhabited Air Vehicles, Rotorcraft

A03-070 TITLE: Merging Sensor and Stored Terrain Database Data for Rotorcraft Poor Visibility Weather Operations

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The objective is to provide the rotorcraft pilot with a display that shows real-time radar, stored terrain database information, and real-time infrared imagery to enable the pilot to fly low level, between terrain features, in poor visibility weather. By definition, this display is an enhanced/synthetic vision display. The nature of the available data sets prevent use of traditional image fusion algorithms.

DESCRIPTION: This effort is primarily a human-engineering display design task and associated human-factors testing of the display. This topic falls under the key technology area of Human Systems.

Different sensors and databases of terrain/obstacles each have advantages and disadvantages. A single data source is inadequate for all environmental and operational conditions. The advantages of radar systems are that these systems detect obstacles such as wires, and do not rely on accurate measurement of aircraft state for the rendering of the data. However, these radar systems tend to have poor resolution, limited range, small field-of-view, and are not covert. The advantages of stored terrain databases are that the rendering is not limited in range or field-of-view. The disadvantages of the stored terrain databases are that the available databases have poor resolution, do not indicate obstacles, and rely on accurate aircraft state information for rendering. The advantages of an infrared image include a much higher resolution than radar or databases, wide field-of-view, and no reliance on aircraft state information. However, the infrared image is unusable in fog and smoke. Therefore a merging of radar, stored terrain data, and infrared imagery will provide the pilot with complementary information regarding the terrain and obstacles.

Since data sources are so different in resolution, field-of-view and range, traditional image fusion methods will not work. The merging of radar, terrain database data, and infrared imagery requires new, innovative, display design concepts and requires the associated software algorithm development. The designer must work under the constraints of night vision goggle compatible colors. To enable covert operations, the display should provide the pilot with sufficient information to avoid ground collision with pilot selectable maximum ranges of radar (selectable power), or without the radar entirely. To enable poor weather operations, the display should provide the pilot with sufficient information to avoid ground collision when no infrared imagery is available.

PHASE I: Based on sound human-engineering principles, develop display concepts for merging or simultaneously showing information from radar, stored terrain database, and infrared imagery. The difficulty is coming up with a design that is:

- intuitive (reduce training time, reduce pilot errors)
- robust (usable when a data source does not work in a particular environment)
- uncluttered (reduce attention problems)
- generalized (can be used on panel mounted, head-up, and head mounted displays)

Deliver an animation demonstrating the display concept(s). Use simulations of existing sensors as far as field-of-view and resolution parameters. Multiple concepts may be animated, for further evaluation in Phase II. Deliver a Phase I report.

PHASE II: Design, fabricate, and deliver a simulation system capable of merging or simultaneously displaying simulated radar data, simulated infrared imagery, and an actual stored terrain database. Overlay a set of primary flight symbology, such as airspeed, altitude, etc. Using sound human factors principles and statistical methods, prove that the new display enables better pilot performance and terrain awareness than current displays (such as USAF search-and-rescue radar systems). Simulate obstacles visible only with the simulated radar. Simulate sharp terrain perturbations not in the terrain database. For at least a portion of the simulation, simulate poor visibility weather (which degrades the infrared image). Deliver a phase II report.

PHASE III DUAL-USE APPLICATIONS: Civil Emergency Medical Services (EMS) helicopter operators can benefit from the proposed enhanced/synthetic vision 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 [Hart S. 2001]. In addition to EMS operators, forest fire fighter helicopter operators can also benefit from the proposed system since they routinely must cancel intended water drops due to limited visibility from smoke.

OPERATING AND SUPPORT COST REDUCTION (OSCR): Reduce helicopter accidents. Increase the visual conditions in which helicopters may operate.

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KEYWORDS: display, enhanced vision, synthetic vision, helicopters, radar, infrared, terrain

A03-071 TITLE: <u>Sensors for Detecting and Monitoring Fatigue Cracks</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: To develop a lightweight miniature sensor with an accompanying data acquisition system that can detect, and monitor fatigue cracks in inaccessible areas of aviation components. Successful development of this technology will provide for early detection and monitoring of fatigue cracks in inaccessible areas to avoid costly repairs, improve readiness, and ensure airworthiness of the Army's fleet of aircraft.

DESCRIPTION: Fatigue is a progressively localized structural change that occurs in a material subjected to repeated or fluctuating strains at stresses having a maximum value less than the tensile strength of the material. This phenomenon can culminate in the initiation of fatigue cracks or fracture after a sufficient number of fluctuations. Conventional non-destructive inspection techniques for fatigue cracks in inaccessible areas usually require the removal of obstructions or disassembly prior to inspecting the desired component. The system envisioned for non-destructive inspection of inaccessible areas is a surface mounted sensor that has the ability to detect fatigue cracks and provide inspection results to an accompanying portable data acquisition system. Complete assessment of fatigue cracking in an aviation component with limited accessibility may require a data acquisition system that can retrieve inspection results from multiple sensors. Development and implementation of this proposed non-destructive inspection technique should offer the following potential advantages: 1) Lightweight, 2) Compatible with rotary and fixed wing systems, 3) Monitoring of inaccessible areas, 4) Reliable and accurate non-destructive inspection technique, 5) Low cost.

PHASE I: Develop a conceptual lightweight sensor and accompanying portable data acquisition system with multiple inputs. This phase should include a laboratory demonstration to show the systems capability in detecting small linear flaws in a sample of aviation components.

PHASE II: Construct and evaluate a field portable prototype system. Demonstrate system by installing on a test aircraft or full scale component, and subsequently monitoring a selection of aviation components with limited accessibility that are prone to fatigue cracking.

PHASE III: Commercialize non-destructive inspection technique that can detect, and monitor for the initiation of fatigue cracks. Prompt identification and repair of fatigue cracks can prevent costly replacements of parts. This non-destructive inspection technique will also benefit commercial aerospace, petroleum, chemical and utility industries as an effective tool for detecting and monitoring fatigue cracks in components with limited access.

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KEYWORDS: Sensors, Fatigue, Non-Destructive Inspection

A03-072 TITLE: <u>Self-Healing Composite Structures</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: SARAP

OBJECTIVE: Maintaining the structural integrity of an aircraft is an ongoing necessity for Army Aviation. In order to reduce or eliminate the cost and time associated with detecting and repairing aircraft structures, a biologically-inspired, self-healing, structural material is desired. Aircraft made from a self-healing composite material would also theoretically last longer and enhance safety. The objective of this effort is to develop a self-healing composite material that can be used structurally in Army rotorcraft. Achieving this objective will enhance Army readiness, increase safety, and reduce maintenance labor, time, and cost.

DESCRIPTION: At present, evaluating the integrity of the aircraft?s structure and repairing damages that may have occurred in flight involves a tedious periodic inspection, high maintenance labor, and significant down-time. Self-healing airframe structures and skins would virtually eliminate this down time as well as increase the aircraft?s safety and life expectancy. Self-healing composite materials must be able to repair damage associated with fatigue cracking and ballistics, while maintaining the majority of the structure?s original properties. In developing the technology, however, care must be taken to ensure that the methodologies are suitable for practical rotorcraft structures, such as stiffened skins and load bearing joints. The self-healing composite materials must also be able to endure the rigors of the non-pristine military rotorcraft environment such as excessive vibration and temperature extremes.

PHASE I: Effort in this phase should consist of developing a methodology for a self-healing capability of composite structures. Shortcomings in existing similar approaches, if any, should be identified and addressed. Suitable coupon and sub-element test specimens should be designed for proof-of-concept testing.

PHASE II: Effort in this phase should consist primarily of sub-element and component testing. This testing should validate the methodology, developed in the previous phase. Component should be a representative of an actual rotorcraft part under realistic loading and environmental conditions.

PHASE III: Effort in this phase should consist of demonstration of the technology on a military aircraft. Both rotary-wing and fixed-wing aircraft can benefit from this technology. Furthermore, civilian interests such as the automotive, medical, and aviation industries can benefit from the application of this technology.

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KEYWORDS: smart structures, self-healing, maintenance, composites

A03-073 TITLE: Advanced Snubber/Damper for Bearingless Helicopter Main Rotor Blades

TECHNOLOGY AREAS: Air Platform

RATIONALE: Current bearingless main rotor would be improved with additional damping for inplane (lead/lag) blade motion. Snubber/dampers on bearingless rotors currently under development exhibit large reduction of lag damping as the amplitude of the blade motion increases, leading to excessive size and weight of dampers in order to accommodate all operating conditions. In addition, current snubber/damper designs account for a large fraction of the rotor cost. The greatest amount of lag mode damping at the lowest cost (both initial and maintenance) is desirable.

DESCRIPTION: Many new helicopters incorporate bearingless main rotor (BMR) technology for improved performance and lower operation and support costs (Ref. 1). Bearingless rotor blades require a snubber/damper between the flexbeam and pitch case, to provide constraint of the vertical motion of the root of the pitch case (control of flap and pitch motion) and damping of the inplane motion (lag damping). Current designs use elastomeric or fluidlastic dampers. The damping obtained for these systems can be marginal or inadequate for the range of flight conditions and environmental conditions they encounter (Refs. 2 and 3). This can result in high damper/flexbeam motion at the regressing lag mode frequency. Potential impacts to the Army include: difficulty with precision control, air resonance instability (potential loss of aircraft), short damper life, and short flexbeam life.

The requirements for an advanced snubber/damper design are as follows, in order of priority:
a) Spring constant of 1000 lb/in and loss factor greater than 1.0 at low amplitude of motion.
b) For large amplitude motion (up to 0.75 in at the 1/rev frequency of 5 Hz, up to 0.75 in at the lag frequency of 3.5Hz; both single frequency and dual frequency), maintain damping at lag frequency at greater than 80% of low amplitude level.
c) Design approach that will produce at least 75% reduction in cost, both purchase and maintenance, compared to fluidlastic damper design.
d) Size less than 6 in.

The goal of this SBIR topic is to provide improvements in the snubber/damper of BMR rotors. Current dampers are strictly passive devises. This topic will consider both passive and active mechanisms. The resulting damper could greatly benefit US military helicopters currently under development (RAH-66, AH-1Z, UH-1Y) that utilize bearingless hub designs.

PHASE I: Phase I will demonstrate the feasibility of the advanced design.

PHASE II: Phase II will complete the development of the design and demonstrate the improved characteristics.

PHASE III DUAL USE APPLICAITONS: A possible Phase III could be development for the RAH-66 Comanche

BMR rotor; potential commercial applications include both US and foreign BMR rotor such as the MD Explorer and EC-135.

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KEYWORDS: lead/lag dampers, elastomeric dampers, rotor instability, bearingless main rotor damper

A03-074 TITLE: Health and Usage Monitoring System (HUMS) for Unmanned Aerial Vehicles (UAV)

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: TUAV PMO

OBJECTIVE: Develop an affordable, flight worthy, Health and Usage Monitoring System (HUMS) for unmanned aircraft. The primary emphasis should be to develop a lightweight system (objective of 3 pounds or less) capable of recording key flight parameters to assess the health of UAV's.

DESCRIPTION: The role of unmanned aircraft in the U.S. Army is growing and will expand in the future. In a manned aircraft, there is a pilot to observe/monitor aircraft status and report problems with the aircraft. However, UAV's do not have the man in the loop to observe/report problems, such as unusual vibrations or system anomalies in temperature or pressure. This information is needed to determine if the UAV needs unscheduled maintenance actions prior to the next mission and to ensure that the aircraft will meet mission requirements. Currently, available HUMS are too heavy and expensive for UAV application. HUMS for UAV application must be capable of recording aircraft system temperatures, pressures, vibrations, and flight parameters. Analysis of the data (diagnostics) can be accomplished either on-board the aircraft or via a ground station. A capability to display and analyze flight data is a system requirement. The display and analysis of the data can be done on a ground station (laptop) or combination on-board the aircraft and ground station. The objective weight for the aircraft system is 3 pounds and must be low cost. To reduce production costs and logistics burden, commercial-off-the-shelf components used in other applications, such as automotive, is encouraged. The system should have adequate durability to tolerate the expected operational environment (sand, dirt, humidity, dust, and rain). UAV's will be deployed with ground forces in forward units in combat situations. As part of the proposal, the offeror should show a general understanding of the needs of the potential applications.

PHASE I: Develop and conduct a feasibility demonstration of the proposed HUMS technology. The demonstration shall be conducted on a laboratory scale and shall validate the critical technical challenges associated with the proposed technology.

PHASE II: The contractor shall further develop the design, fabricate a prototype unit, and fully demonstrate the capabilities by conducting additional bench or rig testing to fully validate the operating characteristics and durability of the proposed system.

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

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KEYWORDS: HUMS, UAV, monitoring, diagnostics

A03-075 TITLE: Composite Fastener Development

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM, Comanche

OBJECTIVE: The connection of composite parts to other structures is an important aspect of fabrication for large structures such as airplanes and helicopters. The use of traditional metallic fasteners is often not appropriate for use with composite materials. Most metals are not compatible with advanced composite materials[1]. Excessive corrosion results when the two materials are exposed to a corrosive environment. Additionally, metallic fasteners compromise the advantages of using composite materials. Minimal component weight is a primary advantage of using composite materials; this advantage is compromised when the structure is assembled with heavy metallic fasteners. In addition, during the assembly of composite parts, excessive stresses can be induced into the composite due to the clamping forces required to torque bolts or install rivets. Even more damaging is the delaminating effects caused when a strong metallic fastener is pressed into a much weaker composite hole. Achieving a tight press fit between a metallic fastener and a drilled composite hole is a compromise that aerospace designers do not like to make. Likewise, composite materials are used to reduce radar signature, use of metallic fasteners negates this advantage, compromising the Stealth technology of the aircraft.

DESCRIPTION: Current composite fastener technology employs a variety of methods ranging from specialized coatings for metallic fasteners to complicated adhesive bonding procedures. Each of these techniques falls short of an optimal fastener for composites. Advanced composite materials such as metal matrix composites (MMC), reinforced plastics (RP) or reinforced epoxy-based materials should be investigated as candidate fastener materials. High temperature composite fasteners, made from ceramic matrix composites (CMC), have already been designed and validated [2]. The successful composite fastener should be made from composite materials that are lightweight, compatible, installed without damaging effects, provide tight fits without causing delamination, and complement the Stealth capability of composite aircraft.

PHASE I. Identify materials and develop preliminary concepts. Develop fastener concepts through design and producability studies. Down select the preliminary concepts by developmental testing and analysis to demonstrate form, fit, and function.

PHASE II. Building on the success of Phase I, fabricated test articles should be developed and tested to substantiate fastener strength. These tests should include static strength and fatigue tests. The test articles should incorporate various composite aerospace grade materials (i.e. carbon, aramid, glass, honeycomb sandwich structures) with joints using multiple fasteners. Additionally, the durability or multiple use capability of the selected fastener concept should be demonstrated along with evaluating potential environmental effects to fastener strength. Radar cross-section analyses should be conducted to address the issue of low radar observability.

PHASE III: It is believed that the technology that results from this SBIR effort will have extensive military and civilian application. Helicopter and fixed wing aircraft will most certainly continue to be developed using composite materials. The market for lightweight composite fasteners should also include commercial/military satellites, launch vehicles, civil infrastructure such as power generation and water treatment facilities, and the construction and automotive industries.

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KEYWORDS: Composite Fastener, Composite Joints, Nonmetalic Fasterners, Nonmetalic Rivets

A03-076 TITLE: Combat Rotorcraft Electromagnetic Interference (EMI) Suppression Technology

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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. 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 comprising technological and/or procedural innovations 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. The system 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
2) MIL-STD-464, Electromagnetic Environmental Effects Requirements for Systems
3) DO-160, Environmental Conditions and Test Procedures for Airborne Equipment
4) ADS-37A-PRF, Aeronautical Design Standards for Electromagnetic Environmental Effects


KEYWORDS: electromagnetic environmental effects, electromagnetic interference, avionics

## A03-077 TITLE: Analysis, Design & Test of Low Reynolds Number Rotors and Propellers

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: The range of unmanned air vehicles currently under development includes a number of extremely small vehicles. The physics of the flow of such vehicles, especially as it relates to the phenomena of flow separation, differs greatly from full-sized vehicles and is not well understood or predicted. Measurements at these flows are extremely difficult because of the very low forces involved. Most such measurements today are directed at steady, two-dimensional airfoil behavior. However, a low-Reynolds number rotor is not two-dimensional and encounters extreme unsteadiness. Thus there are major analysis and testing difficulties that limit the ability to design optimum low Reynolds number rotors. The object of this solicitation is to develop the means to design and analyze small rotors, and to test and understand these flows (that is, to achieve a good comparison of analyses and tests and to be able to account for the differences seen).

DESCRIPTION: This problem requires the development of practical design and analysis methods for the total flow of low-Reynolds number rotors. The analyses should be physics-based and include all relevant phenomena including flow separation and all significant interactions. The analysis should be able to treat complex configurations including multiple rotors, ducts, and adjacent surfaces such as wings. The design capability should permit the selection of an optimum configuration consistent with configurational/operational constraints and with any known (from experimental or analytical sources) physical behaviors. The limits of this optimal design should be predictable from the analysis. The capability of these tools should be demonstrated in the fabrication and testing of suitable models.

PHASE I: Devise an analysis method and a related design concept suitable for simple rotors. Demonstrate the ability to predict flows (and related performance) over a single isolated rotor with a tip Reynolds number varying between 500,000 and 20,000. Show the variation in airfoil performance from root to tip for this Reynolds number range (including a comparison with 2D airfoil behavior). Demonstrate that at low Reynolds number the hover figure-of-merit is consistent with the behavior of known small rotors. Propose small-scale test techniques for the validation of rotor analyses and diagnoses of behavior over a full range of advance ratios.

PHASE II: Develop a configuration optimization and layout method for the rapid design of small rotor configurations with a full range of practical constraints. This design tool should be able to incorporate all available test data as possible input. Complete development of the analysis method shall be demonstrated in Phase I. This method should include the ability to treat hover and forward flight and to include ducts and adjacent wings. For configurations of extreme geometric complexity, it would suffice to model distant elements in a practical and physically reasonable manner. Develop and demonstrate a test and validation method for use with this analysis. The demonstration shall include a small range of rotors and/or rotor/ducts sufficient to show the effectiveness of the analysis for a range of geometries.

PHASE III DUAL USE APPLICATIONS: It is anticipated that miniature flying rotorcraft will be useful for a wide range of military and non-military applications. Because such models are fairly cheap and easy to fabricate there will be a major premium on the ability to design and build these rapidly for fast developing applications. This capability would be provided by the sought-for design, analysis and validation complex.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: At the size rotor that is envisioned here, cost is anticipated to be relatively small on the condition that the small rotorcraft is available for the specific application. It is anticipated that this availability will be contingent on the ability to custom design or modify these as required (at least until such time as operational experience identifies the reasonable range of configurations). Of course, if these mini-rotorcraft are not available then the job will have to be done by more conventional and much more costly means.

REFERENCES:
1) "Analysis and Design of Rotors at Ultra-Low Reynolds Numbers," Peter J. Kunz, Roger C. Strawn, AIAA 2002-0099, 40th AIAA Aerospace Sciences Meeting and Exhibit, 14-17 January 2002, Reno, NV.

KEYWORDS: rotors, stall, separation, miniature rotors, low Reynolds number, test, aerodynamic analysis, design

A03-078 TITLE: High Strength, Affordable Helicopter Gears

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PM Apache

OBJECTIVE: Affordably improve the contact fatigue and bending fatigue strength of helicopter gears by at least 25%.

DESCRIPTION: There is a need to increase main gearbox power densities with minimal affect towards gearbox interfaces or growth within the Army's rotorcraft Force Modernization Fleet. Recent advances in gear manufacturing, processing and finishing make it possible to realize dramatic increases in contact fatigue strength and bending fatigue strength for helicopter transmission gears. It may be feasible to integrate several different processes to maximize potential benefits. Instead of growing the gearbox to accommodate the higher power density requirement, it may be possible to keep the gearbox fixed in size and weight, by exploiting these manufacturing processes. These processes include, but are not limited to, chemically accelerated isotropic finishing, near net shaped forging, and ausform finishing.

PHASE I: Demonstrate potential for at least 25% improvement in bending fatigue strength and contact fatigue strength for Pyrowear 53 steel material through material coupon testing. Testing shall include single tooth bending fatigue and contact fatigue. The number of test specimens used will be statistically significant, in accordance with industry common practice. Testing will incorporate a baseline.

PHASEII: Demonstrate process on Pyrowear 53 spur gears representative of a current helicopter aircraft main gearbox. Goal is to demonstrate strength increase of at least 25% by testing the development gears in a 200HR endurance gearbox test. The test rig will be capable of confirming 25% fatigue life enhancement.

PHASE III DUAL USE APPLICATIONS: Demonstrate producibility and the affordability of the high strength gears. Develop an implementation plan for the manufacturing/post-manufacturing process with a Process Specification. Implement 200 Hour iron-bird endurance qualification test. Then flight test gearbox. Potential commercial applications include helicopter gearboxes, tank transmissions, hydraulic pumps, race car transmissions, turboprop engines, earth moving equipment, wind turbine generators, and UAV/SUAV high-performance gearboxes.

REFERENCES:
1) Swiglo A. A., 2001, "Enhanced Surface Protection of Precision Gears," INFAC Program, IIT Research Institute. AMCOM Contract DAAJ09-95-C-5046.
2) Britton R. D., Elcoate C. D., Alanou M. P., Evens H. P., Snidle R. W., Proc. STLE/ASME Tribology Conference; Orlando, FL (1999) "Effect of Surface Finish on Gear Tooth Friction."

KEYWORDS: power density, surface finish, superfinish, ausforming, aerospace gears, transmission, near net forge, fatigue life.

A03-079 TITLE: Miniature Inertial Reference System

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO Aviation (Comanche)

OBJECTIVE: Design and build a very small, lightweight miniature inertial reference system that can be integrated into an aviator's flight helmet to accurately measure the position of the pilot's head and the direction of the pilot's line of sight in real-time.

DESCRIPTION: Knowledge of the position and the orientation (line of sight) of the pilot's head can increase both the safety and the effectiveness of aviation missions. This information can be used to improve the stabilization of imagery that is captured by the aircraft's sensors and displayed in the cockpit for better pilot awareness. These measurements are also essential to head-tracking systems that automatically point sensors or weapons to a target as cued by the pilot's vision. One of the existing technologies that measures the head position does so by creating and detecting magnetic fields. Although this technique is useful in many environments, the interaction of the electromagnetic fields and some of the materials in the cockpit can produce erroneous readings. Some of the existing systems cannot operate in real-time, and many require a complex mapping of the cockpit and/or a time consuming initialization before the system can be used. Additionally, the slightest change within the cockpit, such as the pilot adjusting his seat or repositioning equipment, will often require a new cockpit mapping or initialization.

Novel techniques for accurately determining the position and orientation of the pilot's head are sought to provide three-dimensional inertial location data. The system design should be integrable into standard Army aviator flight helmets. Emphasis should be placed on minimizing the weight of the system and insuring the system does not block the pilot's vision or otherwise inhibit his ability to safely perform the mission under all realistic flight conditions.

PHASE I: Design a system to determine the position and orientation (line of sight) of the pilot's head. Provide an estimate of the expected accuracy of these measurements. Develop a plan to integrate the system into the pilot's helmet and to relay the information through existing communication channels into the aircraft computer.

PHASE II: Develop and demonstrate a prototype system. Conduct testing to verify both the system performance and the ability to interface with the aircraft computer(s).

PHASE III DUAL USE APPLICATIONS: This system can benefit both the military and the commercial sectors. Reliable and accurate position and pointing information can be utilized in remote tracking, robotics, entertainment, surgical, and surveillance applications.

REFERENCES:
1) Ferrin, Frank J., "Large Screen Projection, Avionic, and Helmet-Mounted Displays," Proc. SPIE, 1456, 86-94 (1991).

KEYWORDS: sensors, inertial reference, tracking

A03-080 TITLE: Small Multi-decade Communications and Electronic Warfare (EW) Antenna

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM FIREFINDER

OBJECTIVE: Develop a miniaturized multi decade bandwidth antenna for omni-directional broadband communications and electronics counter measures.

DESCRIPTION: The Army is relying on a wide range of Radio Frequency (RF) systems for communications, navigation, combat ID, and electronics counter measures. In addition the Army is becoming increasingly mobile with smaller forces of greater capability. As a result, the Army needs smaller, wider bandwidth, and more capable antennas. The RF band from 20 MHz to 2000 MHz is of particular interest as it encompasses a wide range of communications, sensors and countermeasures systems. Current initiatives include the Army Sensor Countermeasure for the Objective Force (SCOF) STO, improved Global Positioning System (GPS), UHF satellite and line-of-sight communications radios, multifunction Joint Tactical Radio System (JTRS), and Shortstop Electronics Protection System (SEPS). The use of separate antennas for each of these systems results in a set of antennas that are individually cumbersome and whose performance is degraded due to interference and blockage from the other antennas. The purpose of this effort is to resolve these problems, by developing an innovative small antenna with greater than 100:1 bandwidth that can be used in a wide range of applications.

The particular emphasis of this program is to develop antennas usable for both man portable and vehicular applications. It is critical that the solutions be small, light weight, low volume, visually concealed and have a low Radar Cross Section (RCS). As an example, typical broadband antennas, such as cavity-backed spirals, are at least 0.32 wavelengths at the lowest frequency of operation. For such antennas, a goal of this effort would be to retain the desirable electrical performance characteristics while reducing the diameter by a factor of 1.5 and the cavity depth by a factor of 2 for a 65% reduction in antenna volume. It is known that smaller sizes can be attained by loading the cavity, but under penalty of higher cost, weight, and greater loss associated with typical loading materials. Under this topic, innovative uses of new low-loss high-permittivity and high-permeability materials are encouraged. In addition, innovative structures with high radiation efficiency, such as photonic band-gap structures, should be considered. It is anticipated that both improved materials and innovative structures will be required in a successful design. The antenna is intended for both receive and transmit functions (up to 100W) and as such aperture efficiency is an important parameter. An efficiency of 50% or greater over the majority of the operating band is desired. The preferred polarization is vertical.

PHASE I: Develop a theoretical model of the antenna. Predict the performance of the antenna in both manpack and vehicular installations. Development and test of breadboard models of the antenna are encouraged but not necessary. Document the design and predicted performance. Assess potential commercial applications and marketplace, and identify any design features/issues impacting dual-use.

PHASE II: Construct and deliver a prototype of an antenna based on the designs of the Phase I program. Tests should be done in an environment emulating the intended applications of the antenna. Generate a report showing the results and comparisons to the theoretical models and any deviations from the expectations.

PHASE III: Many commercial systems have requirements for broadband small antennas. Perfect examples are commercial and general aviation A/C industry with numerous antenna systems that are being added to all A/C for a variety of applications. Other good examples are vehicular and personal communication antennas for a wide range of communication and navigation applications. It is expected that successful results of this effort will easily find applications to a wide range of commercial systems.

REFERENCES:
1) Frequency Independent Antennas Jaisk and Johnson.
2) Kraus, John D. Antennas, McGraw-Hill Book Co. Inc., NY 1988.

KEYWORDS: Antennas, Broadband, Communications, Electronic Warfare (EW), Radio Frequency (RF), Global Positioning System (GPS), Joint Tactical Radio System (JTRS), Shortstop Electronics Protectin System (SEPS), Radar Cross Section (RCS), Future Combat Systems (FCS), (Sensor Countermeasure for the Objective Force (SCOF)

A03-081 TITLE: Blockage Mitigation Techniques for On-the-Move Satellite Communications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM WARFIGHTER INFORMATION NETWORK-TACTICAL

OBJECTIVE: Design and build a blockage mitigation capability suitable for use with small Ka-band and Extremely High Frequency (EHF) satellite communications terminals operating on the move. This capability must include a Satellite Communications-On-The-Move (SOTM) protocol that encompasses acknowledgement-based protocols to recognize disruption in service and to employ appropriate correction techniques. Protocol analysis needs to ensure signal quality is maintained in the presence or random errors during transmission, as well as maintaining quality of service (QoS) if the signal is blocked. Appropriate forward error correction (FEC) and automatic repeat request (ARQ) techniques need to be developed and analyzed to define the optimum implementation strategy to maintain QoS within the network.

DESCRIPTION: Communications while on the move is an important requirement for the Army's Future Combat System/Objective Force (FCS/OF). Satellite communications (SATCOM) will be a vital part of the future communications architecture. However, both urban and rural terrain presents many obstacles (i.e., buildings, mountains, foliage, etc.) that block satellite signals and interrupt voice and data transmissions for tactical vehicles communicating while on the move. FCS/OF SATCOM needs technology to ensure that voice and data communications are received in full despite interruptions during transmission from blockage without using excessive amounts of limited SATCOM bandwidth. Existing efforts primarily address on-the-move antenna pointing and transport layer issues (e.g., Transport Control Protocol issues). Additional approaches are needed at the physical, data link and network layers to achieve a comprehensive, robust blockage mitigation capability for networks of on-the-move satellite terminals. Consideration of time tracking and signal acquisition under low Bit Energy-To-Noise Power Density Ratio (Eb/No) conditions are also important aspects of blockage mitigation. Without this capability, communications among the networks of numerous small Ka-band and Extremely High Frequency (EHF) on-the-move satellite terminals envisioned by the Warfighter Information Network–Tactical (WIN-T) and FCS/OF architectures will be adversely effected by the signal blockages expected in most types of terrain. This will result in less robust networks and inefficient use of satellite resources in the face of frequent signal blockages.

PHASE I: Develop overall system design that includes specification of the blockage mitigation techniques, how they interact with other elements of a three-dimensional communications network (terrestrial, airborne relay, and satellite), the impact on satellite terminal design, and how they can be expected to perform in a networks of small, on-the-move terminals.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions and ability to support networks of numerous small terminals.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian communications applications where there is a need for on-the-move satellite communications – for example, in overseas peacekeeping operations, emergency response/disaster relief operations, mobile news coverage, and in-vehicle business communications and entertainment systems.

REFERENCES:
1)Army Vision of Future SATCOM Support, http://www.army.mil/ciog6/references/armysat/Chapter_12.PDF
2) Space Communications Protocol Standards (SCPS) Homepage, http://bongo.jpl.nasa.gov/scps/
3) Employment Of ACTS Mobile Measurements At 20 GHz For Prediction Of Earth-Satellite Fades Due To Trees And Terrain, http://acts.grc.nasa.gov/docs/SCAN_20010910164047.PDF
4) Encryption And Error Correction Using Random Time Smearing Applications To Mobile And Personal Satcom, http://acts.grc.nasa.gov/docs/SCAN_20010913161741.PDF
5) Finite State Markov Models For Error Bursts On The ACTS Land Mobile Satellite Channel, http://acts.grc.nasa.gov/docs/SCAN_20010911124730.PDF
K/Ka-Band Channel Characterization For Mobile Satellite Systems, http://acts.grc.nasa.gov/docs/SCAN_20010911145550.PDF

KEYWORDS: satellite communications, SATCOM, networking, protocols, blockage mitigation

A03-082 TITLE: Extensible Markup Language (XML) Compression Tool

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, Soldier Warrior

OBJECTIVE: Develop a software-based XML compression tool that will compress and encode XML data prior to transmission over a network.

DESCRIPTION: This software XML compression tool must operate in a transparent fashion to the user once installed, intercepting datastreams from an application prior to transmission out over the network. It should have the capability of using a highly-efficient encoding algorithm for XML data for which knowledge about the Schema and DTD is well-known for both the sending and receiving application, as well as a less-efficient algorithm for transmitting XML data in which either the Schema is not well-defined or the recipient has little knowledge about the data?s structure. With the proliferation of XML in military systems and its associated high overhead for its tagging structure (sometimes exceeding 90% overhead versus data), this tool can reduce transmission and bandwidth requirements by a factor of 10 or more. Since the military typically operates over wireless transmission channels in the battlefield with limited bandwidth, such an information management savings will be essential to meet the demands of the Future Combat System and Objective Force. Also, with XML gaining wide acceptance in the commercial world, as well as the widespread use of mobile users, this tool could have an extremely large commercial market to exploit.

PHASE I: Research algorithms and methods to rapidly encode XML data utilizing a software-based approach. The techniques must be capable of compressing in real-time or near real-time an XML data stream prior to transmission over a wireless or wired link. It must also have the capability to decode a received stream of encoded data in near real-time.

PHASE II: Develop a software tool based on the algorithms researched during phase I to perform real-time or near real-time encoding and decoding of XML data streams. This software should be able to be ported to numerous platforms, ranging from workstations and servers to desktop computers, laptops, wearable computers, and personal digital assistants. Porting to web-enabled phones would be a plus.

PHASE III: Fieldable software tool that will be used with battlefield systems to compress XML data prior to transmission over the battlefield and de-compress these streams at the receiving end. Commercial plug-in software modules that could compress/decompress XML files to reduce transmission time and overall file size prior to transmission over a commercial network.

REFERENCES:
1) XML and compression - see http://www-106.ibm.com/developerworks/xml/library/x-matters13.html.
2) Army Joint Technical Architecture - see http://www-jta.itsi.disa.mil/

KEYWORDS: XML, data compression, web technologies, eXtensible Markup Language, Internet, web, web services, data formats, enterprise systems

A03-083 TITLE: Military 3-D Visualization Utilizing Gaming Technology

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PM, Future Combat Systems

OBJECTIVE: Develop a standardized application programming interface (API) for a military 3-D gaming simulation tool that will facilitate the integration of a gaming environment with planned military C2 applications (such as the Commander's Support Environment, Combined Arms Planning and Execution System, DaVinci Toolkit).

DESCRIPTION: This 3-D visualization interface will be required to work with a standard C2 Data Model and associated XML Schema and DTD to render 3-D visualizations of military units, as well as have the desired capability to render 3-D terrains and environments from standard NIMA maps and imagery. The simulation tool should be capable of taking live feeds from the associated military planning tools in a networked environment (multiple feeds desired) and rendering a 3-D virtual environment in near real-time for war-gaming scenarios. The API developed as part of this effort should be robust and extensible to allow for integration of live sensor feeds at a later date. Currently, no standard gaming API exists in the industry, which hampers the rapid development and application of gaming technology to large-scale simulation systems and trainers. (Each system becomes a custom environment.) The system should leverage commercial standards to the maximum extent and leverage existing gaming engine technology. It is desired that the system be capable of running on a current Windows 2000 environment, but Unix/Linux based systems will be considered. Development of such a system will directly support all Future Combat System experiments, which currently employ the Commander's Support Environment. Commercial applications include the use of such a system for Homeland Security, both in stand-alone exercises of non-military emergency personnel, as well as joint operations between civilian authorities and NORTHCOM. Commercial applications also allow gaming manufacturer's to develop an industry-standard interface to allow for gaming applications to be used as simulation trainers for various commercial environments.

PHASE I: Research current 3-D visualization techniques that are generated in real-time on desktop computing platforms utilizing commercial gaming engines and develop a systems architecture to incorporate these systems into Future Combat Systems C2 operational software. The systems should have the capability of interoperating with a command and control object model based on the DaVinci architecture, along with the ability to read XML data streams as input drivers to the system to effect movement of the objects during an operation.

PHASE II: Develop a prototype 3-D visualization system and API that can be integrated into the Future Combat System C2 application based on the DaVinci architecture and its associated object model, XML Schema and DTD. As part of this effort, verify the validity of the API by demonstrating a working prototype where the existing the C2 application input/output effects are displayed in 3-D form using the visualization engine in a laboratory environment over a wired network.

PHASE III: Future Combat System applications. This 3-D visualization system can also be used in commercial simulation scenarios for Homeland Security and Disaster Relief and Recovery systems for both civil defense and corporate applications.

REFERENCES:
1) Future Combat System - See http://www.darpa.mil/fcs/index.html
2) DaVinci Architecture - See http://call-ditt.leavenworth.army.mil/docs/CECOMBAA001.htm;
3) DaVinci Architecture - Also see diicoe.disa.mil/coe/aog_twg/twg/mstwg/agile_brief.ppt

KEYWORDS: 3-D visualization, game engines, gaming technology, XML, DaVinci, C2, command and control, Future Combat Systems

A03-084 TITLE: Ultrafast Charging of Smart Lithium Ion Rechargeable Battery Hybrid Power Sources

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: PM Soldier

OBJECTIVE: To develop safe and ultrafast recharging on Smart lithum ion Rechargeable battery without using a large power supply. Since we developed the charger on the move for front line soldier, it is becoming very important to be able to recharge the battery in less time at the front line. It can reduce the logistic to bring a large amount of batteries to the field and recharge the battery at where that is needed.

PHASE I: Identify and investigate by using a large lithium ion battery to recharge the small lithium ion battery such as LI7 land warrior battery.At what size the battery is required to recharge the LI7 ( which consisted of 16 18650 cells connected 4 in series and 4 in parallel)within half hour.

PHASE II: Fabricate and demonstrate the energy density, safety aspects and cycle life capability in the LI7 lithium ion Land Warrior battery.

PHASE III: Fabricate another system that can recharge a higher energy rechargeable battery like ITAS battery and a 100 AH lithium ion battery. This will set a base for future electric vehicle battery to be recharged in less than half hour.

REFERENCES:
1) A. Deanni, L. Cristo, A. Pellegrino, and G. Au, " Smart SMBus Lithium ion Battery for Land Warrior " at Best Western Golden Sails Hotel, Long Bech, CA, 20-21 Feb 2002.

2) S. Slane, A. DeAnni, and R. Scarinzi, Maj. J. Raftery, and G. Au, “ Effect of Li-ion Charge Variance on Performance of a New Soldier System Battery”, Proceedings of the 40th Power Sources Conference, Cherry Hill, NJ, 10-13 June, 2002, page 520-523.

3) George Au, Laura Locke(cristo) and Jon Rafferty, " Performance and Characteristic of a large Lithium ion Cell with Low Temperature Electrolyte for U.S. Army Application", Proceedings of 16th Annual Battery Conference on Application and Advances, Long Beach CA, 09-12 Jan 2001, page 17-22.

KEYWORDS: Charger, lithium ion battery, smart charger, ultrafast charger, large lithium ion battery.

A03-085 TITLE: Lithium-Air Technology

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To provide the warfighter with a small light weight lithium based power source that maximizes both specific energy and specific power. To give the warfighter extended mission times without an added portage burden. Developed electrochemical system that allows for covert forward missions due to a decreased signature.

DESCRIPTION: Recent novel research has shown that a Li-air battery utilizing a nonaqueous electrolyte solution is capable of delivering extremely high capacities, in excess of 1000 mAh/g based on the mass of the carbon content of the air electrode. However, many problems have to be solved before this novel system can be integrated into the military and commercial markets. For example: shelf life has not been demonstrated, safety concerns have yet to be addressed and performance at low temperatures has not been demonstrated. The problems concerning shelf life and safety are highly dependent upon water introduced into the Li-air cell from atmospheric water vapor. The successful development of a Li-air battery will have major impact on a number of military programs, in particular, the Army's Land Warrior (LW) and Objective Force Warrior (OFW) programs.

PHASE I: Identify cell components which meet performance and safety requirements for a Lithium-Air electrochemical system. Fabricate proof of concept laboratory cells (20 mAhr or greater) for test and evaluation. Shelf life and safety of cells shall be addressed.

PHASE II: Develop and demonstrate Lithium-Air electrochemical system employing laboratory cells (100 mAh cells). Fabricate laboratory cells (100 mAhr) for test and evaluation. Performance (1000 mAhr/g), shelf life and safety shall be addressed. This phase shall address each component of the lithium-air electrochemical system. Areas of the lithium air cell to be addressed include: anode, electrolyte, cathode and containment.

Anode: Evaluate metallic Li anodes which exhibit decreased reactivity with water.

Electrolyte: Develop nonaqueous and gelled electrolytes designed to minimize water solubility and/or contain water gettering additives.

Cathode: Develop air cathodes which possess maximum efficiency for oxygen reduction (catalyst, kinetic and mechanistic studies) and simultaneously reject atmospheric water and selectively enhance O2 concentration over N2 concentration.

Containment: Establish packaging protocol for developed Lithium-Air system. This area includes separators and cell containment focusing on safety and shelf life of the cells.

PHASE III: Target Applications for Phase III include: 1) power source for remote and unattended sensors, 2) Forward field charging energy source, and 3) Energy component for battery/battery hybrid power sources for long term missions.

REFERENCES:
1) K. M. Abraham and Z. Jiang, J. Electrochem. Soc. 144, 1 (1996).
2) J. Read, J. Electrochem. Soc. 149, A1190 (2002).
3) M. Salomon, H.-p. Lin, E. J. Plichta and M. Hendrickson, chapter 11, "Temperature Effects on Li-Ion Cell Performance" in Advances in Lithium-Ion Batteries, W.A. van Schalkwijk and B. Scrosati, eds., Kluwer/Plenum, NY, 2002.
4) K. Takechi and T. Shiga, US Patent 6,235,431, May 22, 2001.
5) Y. Nishi, chapter 7, "Lithium-Ion Secondary Batteries with Gelled Polymer Electrolytes" in Advances in Lithium-Ion Batteries, W.A. van Schalkwijk and B. Scrosati, eds., Kluwer/Plenum, NY, 2002.
6) B. Scrosati, chapter 8, "Lithium Polymer Electrolytes" in Advances in Lithium-Ion Batteries, W. A. van Schalkwijk and B. Scrosati, eds., Kluwer/Plenum, NY, 2002.
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9) R. Battino, "Oxygen and Ozone" Volume 7 in the IUPAC Solubility Data Series, Pergamon Press, London, 1981.
10) R. Battino, "Nitrogen and Air" Volume 10 in the IUPAC Solubility Data Series, Pergamon Press, London,

1984.
11) A. Brokman and J. Goldstein, US Patent 5,185,218, February, 1993.
12) J. Goldstein, N. Naimer, E. Khasin and A. Brokman, US Patent 5,190,833, March, 1993.
13) R. E. Moore, "Preparation of a Gel Having Gas Transporting Capability," US Patent 4,879,062, November, 1989.
14) J. R. Spears, "Stabilized Gas-Supersaturated Suspensions and Methods for Their Delivery," US Patent 6,461,590, October, 2002.
15) H. H. Yong, H. C. Park, Y. S. Kang, J. Won and W. N. Kim, J. Membrane Science, 188, 151 (2001).
16) Y. S. Kang, B. Jung, U. Y. Kim, "Polymeric Dope Solution for use in the Preparation of an Integrally Skinned Asymmetric Membrane," US Patent 5,795,920, August, 1998.

KEYWORDS: Lithium-Air, Metal-Air, Advance Electrochemical System

A03-086 TITLE: Commanders Portal Technology

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop software technology to permit a commander to design a configurable current situation monitoring display composed of user interface components selected from a set of display objects such that the selected objects may be individually configured to represent various aspects of the situation within the display.

DESCRIPTION: Future battlefield commanders will be offered a potentially overwhelming assortment of data upon which they must make their decisions. One of the challenges of modern warfare will be to develop technologies that permit the commander to more easily determine what is important and what is not. Current component software technology suggests that it would be possible to build a collection of interface objects that encapsulates both a user interface and the ability to gather current information for display from a range of available external sources. Such a system would allow a commander to design a display panel by dragging and dropping instances of display components representing different user interfaces. The commander could then connect each display component to different information sources or to each other. A component could, for example, mimic a ?paper strip chart? and display several values over time using different colors. Another component could perform some processing, such as filtering, on incoming data and then feed the resulting data to another component for display. It would also be useful for the commander to be able to specify out of limit levels for components that would result in alert displays if values fall outside the set points. Such a system should be expandable by permitting the easy definition of new display components and data sources.

PHASE I: Develop an overall system design that includes typical display components, processing components and data sources as well as a mechanism for introducing new components and data sources.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over a range of operating conditions and input sources.

PHASE III DUAL USE APPLICATIONS: This system could be used in a range of military and civilian applications whenever an on-going situation needs to be monitored. Examples might include battlefield current situation monitoring, homeland security situation monitoring, resource monitoring and situational analysis.

REFERENCES:
1) Jef Raskin, The Humane Interface: New Directions for Designing Interactive Systems, Addison-Wesley, 2000. ISBN: 0201379376.
2) Matthew Macdonald, User Interfaces in VB.NET: Windows Forms and Custom Controls, APress, 2002. ISBN: 1590590449.
3) Howlett, V. Visual Interface Design for Windows. Wiley: New York, NY, 1996.

KEYWORDS: situation monitoring, configurable display, display components, interface objects, alert displays, interface components

A03-087 TITLE: Use of Cognitive Systems in Generation of Course of Action

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To assist the warfighter with a software tool to rapidly conceptualize and prioritize relevant information. To provide the Objective Force decision-maker with a powerful and fast information processing tool. This software tool will be able to operate on textual messages, which describe distributed sensory data, terrain, situational awareness (SA) and common operational picture (COP).

DESCRIPTION: The information exchange in the battle space is done using Natural Language in the form of either speech or text. The 'understanding' of Natural Language by the computer, or at least a constrained language such as Battle Command Language (BML) [S. A. Carey, et al 2001], can be achieved when linguistic concepts are grounded in the relationships between battlespace entities and the physical world. Also, the wealth of data residing within the nodes of existing C4ISR systems is virtually untapped. The proposed cognitive system can tap into these data resources and with the aid of entity relational functions [P. Chen 1976, and A. M. Meystel, J. S. Albus, 2002], rapidly provide the Objective Force Warrior with time critical information. The cognitive system forms an associative relationship between battlespace objects and variables. The functions that are used in computing these relationships are derived from the doctrine, rules of engagement, and ontology and can be user defined. The proposed cognitive system will use existing methods of Course of Action development and analysis to validate, correlate and relate information content to the battlespace. This should allow the critical elements of the informational content to emerge as a result of the Course of Action analysis.

As the information is received, its content should be parsed into different functional domains and different levels of resolution. An entity relational network will be formed to prepare the information for analysis. The advantages of this approach should results in a very fast information retrieval, since the information is continually segmented into task relevant knowledge repositories. The cognitive system will be provided as add-on software to existing systems.

The cognitive system will be able to operate very fast on very large sets of C4ISR data. By clustering the data at several levels of resolution, the software will allow better and faster decisions at the tactical, strategic, and operational levels.

Examples of applications are:
1. Course of Action analysis
2. Planning
3. Friend-or-foe deconfliction
4. Fast asset allocation
5. Multiple time critical target tracking, weapon selection, deconfliction
6. Survivability, lethality and responsiveness enhancements.
7. On-the-move mission execution monitoring.

PHASE I:
1. Research and propose a suitable architecture to support a cognitive system functionality to allow Natural Language or its subset the Battle Management Language (BML) to be understood by a computer. This architecture should provide a conceptual framework between battlespace entities such as terrain, resources and Natural Language.
2. Develop a software model to demonstrate the proposed architectural concept.
3. Provide a small conclusive metrics via experimental results to demonstrate superiority of the proposed architecture as compared to, for example, using current state-of-the-art Internet-based information retrieval technology.

PHASE II:
1. Develop and demonstrate a realistic C2 or a C4ISR application of a cognitive system to C4ISR using the architecture developed in Phase I. Develop the necessary software using a minimum of a 500-word vocabulary

(BML based), to
a. Demonstrate ability of a computer understand and appropriately react in response to free text messages
b. Understand commander's intent and provide a warning with explanation if the intent is deviated
c. Use Planning or Course of Action analysis to demonstrate system capabilities
2. Provide conclusive metrics via experimental results to demonstrate superiority of the developed software.

PHASE III DUAL USE APPLICATIONS: The resulting framework allowing a computer system to use Natural Language as input, is useful for retrieving information based on concepts rather than key words.

Examples of Military applications are: Objective Force, Network Centric Warfare, and Future Combat Systems.

Examples of Commercial are: Law Enforcement, Homeland security, Internet Search Engines, and any Man-Machine Interfaces using textual or verbal inputs

REFERENCES
1.) [S. A. Carey, et al 2001] S. A. Carey, M. S. Kleiner,. M.R. Hieb, R. Brown, "Standardizing Battle Management Language - A Vital Move Towards the Army Transformation, 2001 Fall Simulation Interoperability Workshop, http://www.sisostds.org/siw/01fall/readlist.htm
2) [J. F. Sowa 200] John F. Sowa, Knowledge Representation: Logical, Philosophical, and Computational Foundations, Brooks Cole Publishing Co, 2000.
3) [P. Chen 1976] Chen P. P, The Entity-Relationship Model - Toward a Unified View of Data, ACM Transactions on Database Systems, Vol. 1, No 1, March 1976, pp 9-36
4) [A. M. Meystel, J. S. Albus, 2002] Alexander M. Meystel, James S. Albus, Intelligent System: architecture, design and control, John Wiley and Sons, 2002.
5) [E. Dawidowicz, et. al 2002] Edward Dawidowicz, Albert Rodriguez, John Langston, Intelligent Nodes in Knowledge Centric Warfare, CCRTS 2002 Monterey, CA, Naval Postgraduate School, 11-13 June 2002, http://www.dodccrp.org/Activities/Symposia/2002CCRTS/Proceedings/Tracks/pdf/101.PDF
6) [E. Dawidowicz and A. Meystel in print] E. Dawidowicz, A. Meystel, "Modeling of Communication Flows in Systems with Intelligent Nodes", in Proceeding of the Workshop on Theoretical Fundamentals of Intelligent Systems, held in March 2002 as a part of JCIS, in Durham, NC.

KEYWORDS: Ultra-fast Databases, Multi-level Resolution, Entity Relational Networks, Knowledge-centric, Controlled Natural Language, Intelligent Systems, Contextual Information, Intelligent Agents, Semiotics.

A03-088 TITLE: Near-Real Time Tactical Automated Machine Translation Technology(N-TAMTT)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Sequoia PEO for Foreign Language Translation

OBJECTIVE: To develop a fully automated Windows-based Machine Translation software system with robust syntactic processing algorithms and large-scale bilingual lexicons with semantic features that will automatically scan/read Modern Standard Arabic (preferably Iraqi dialect, idioms and taxonomy) documents and translate them between English and Arabic text with high quality accuracy (preserve original meaning ) between 80 to 90 percent accuracy based on quality levels and pre-existing government scales for adequacy, informativeness, and intelligibility. This SBIR will also provide tremendously needed MT capability for use in the joint and multinational coalition environment.

DESCRIPTION: Every hour, millions pages of documents in Arabic languages are transmitted via email, fax, regular mail and other forms of media to known and questionable destinations. Only a small portion of the transmitted data is of any interest or value to the "Intelligence Community and governmental agencies". These activities have a requirement to access, retrieve, understand, share, analyze, correlate, store and publish information of intelligence value to national and international organizations. In addition, warfighters may capture documents for which they need to determine their domain and translate the text which might contain critical enemy information.

Warfighters are also engaged in coalition operations which require joint collaboration in the planning, rehersal and execution of military operations with Arabic speaking allies. Because the Arabic language has more complex inflectional morphology than other languages and lexically is more ambiguous, it creates unusually dense translation ambiguities that impede computational analysis, interpretation and translation of large texts in a time constrained environment. Despite many available commercial Arabic MT systems in the market, there has yet to be a commercial-grade MT software product that can satisfactorily meet the Army's large volume of Arabic into English MT requirement and the high quality level needed for coalition warfare. The Army requires the application of "next generation MT software" to address the urgent NLP MT difficulties associated in persevering the meaning of Arabic to English as well as English to Arabic. To that end, 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 N-TAMTT, Corpus-based MT, combination of a linguistic approach with a statistical approach to fine-tune the alignment and enhance processing of bilingual corpora in order to develop design and demonstrate basic functionalities of a totally integrated and fully automatic functioning MT software module with capability to:

a- Translate between Arabic and English text with 70 to 80% accuracy using a representative but restricted lexicon.

b- The restricted lexicon will cover three 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"), 3) Coalition warfare.

c- Detect context of the document (e.g. medical document, engineering specification document, newspaper article, business letter, etc.) with an accuracy of 50% or more

d- Determine the main subject of the document, summarize and classify its contents before translation into English with an accuracy of 20% or more

e- Develop a preliminary user's manual.

f- Define comprehensive plans; including detailed engineering specifications, methodology, estimated man-years and requirements for enhancements to make System practical commercial-grade software upon completion of Phase II

(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 continuation of Phase I with the aim of developing a fully integrated and functioning prototype system or components, which should have dual use market potential. Under Phase II, the bidder will demonstrate capabilities with commercial components. Prototype should be mature enough to attract commercial venture capitals for full product release making the prototype into a commercial-grade product, by making enhancements and using findings of Phase I.

a- Reject duplicated items with 95% accuracy

b- Translate between Arabic and English text with 80 to 90% 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 module 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 , P. O. Box 218, Yorktown Heights, NY 10598 USA-email: reports@us.ibm.com
Donna M. Gates, Carnegie Mellon University, Pittsburgh, USA dmg@cs.cmu.edu

Some reports are available on internet at:
1) http://domino.watson.ibm.com/library/CyberDig.nsf/home
2) Evaluation of Machine Translation Output for an Unknown Source Language: Report of an ISLE-Based Investigation by: Keith J. Miller, The MITRE Corporation, Washington D.C., USA keith@mitre.org
3) Computational Linguistics Formalisms for MT: http://wings.buffalo.edu/linguistics/rrg/
4) Lexical Functional Grammar http://www-lfg.stanford.edu/lfg/
5) GOTs MT/NLP tools: http://www.geocities.com/gyaeger123/NLP/index.htm
6) View Army knowledge on line. Look for US Army transformation and the Objective Force (OF) at: http://www.army.mil.
7)- Toward Corpus-Based Machine Translation for Standard Arabic: http://accurapid.com/journal/19mt.htm
8) Latest Developments in Machine Translation Technology- Beginning a New Era in MT research: http://ourworld.compuserve.com/homepages/WJHutchins/MTS-93.htm
9) Work Shop announcement- Computational Approaches to Semitic Languages http://www.cs.um.edu.mt/~mros/WSL/
10) Predicting Intelligibility from Fidelity in MT Evaluation by: John White Litton PRC, 1500 PRC Drive, McLean VA 22102 white_john@prc.com
11) In One Hundred Words or Less by: Florence Reeder MITRE Corporation- 7515 Colshire Drive, McLean, VA, 22102 USA freeder@mitre.org
12) Firms with text to text Arabic/English and English/Arabic commercial translation products :
http://www.sakhrsoft.com/
http://www.almisbar.com/salam_trans.html

KEYWORDS: Arabic/English-English/Arabic Machine Translation, parallel corpora, Corpus linguistics, translated corpus, corpus alignment, OCR, MT Accuracy, fidelity, intelligibility, and evlauation-, diversified forms of data/documents,

A03-089 TITLE: Integrated Search and Discovery Portal

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Battle Command Battle Lab(Leavenworth)

OBJECTIVE: The Army mission was broadened after 9/11 when the Army became a key player in Homeland Security(HLS). Because of this, the Army information superiority needs also broadened and mission readiness and response time requirements decreased. For these reasons, Army commanders need contextually-relevant, time-sensitive information from other HLS organizations to execute their mission. The Army Homeland Security mission requires sharing information with other DoD and non-DoD organizations in support of HLS. Relevant HLS information is distributed in diverse formats and reside in disparate databases. Not only are there a diverse set of products across HLS partners, relevant information is difficult to locate in a timely manner. In addition, the information is owned, updated and maintaned in a highly distribued and often isolated environments. Information that the Army needs may exist somewhere, but the Army may not be aware of its existence. The Objective Force needs an integrated capability to search, parse, discover, mine, and adapt data, information and knowledge entities in collaboration with DoD and non-DoD partners.

DESCRIPTION: Current information technologies are not sufficiently integrated and interoperable to meet the needs of a network-centric world of information. This effort will explore newer and more innovative ways to dynamically search, parse, discover, mine, adapt, federate, collaborate, interoperate, manage, access and share information. It will create an environment in which information and knowledge bases will be able to: (a) learn from each other, (b) apply reasoning tools to identify and supply missing information found in other information and knowledge bases to form more complete picture for current situation awareness, trends, and understandings. This R&D effort will investigate promising and evolving information technologies and innovative ways to integrate them to meet the Army HLS information superiority needs. This functionality must provide the capability to dynamically search, discover, parse, adapt heterogeneous data, information, and knowledge. This R&D will also determine how the Army may need to transfom in sharing information with other organizations that support HLS missions. This effort should result in new ways to make information more accessible and semantically compatible to integrated systems such as FCS the Objective Force and associated non-Army HLS systems.

PHASE I: Research and conduct a feasibliity study to determine what new information superiority technologies such as search engines, parsers, discovery, mining, adaptors, federation, collaboration,and interoperation mechanisms are emerging to support future Army information requirements. Propose a proof of concept for utilization and integration of the selected technologies.

PHASE II: Design new integrated information warehousing and portal environment and develop a prototype. Demonstrate the prototype using an Army information system and at least one other DoD and one non DoD HLS organization.

PHASE III DUAL USE APPLICATION: This system could be used at the new HLS Department to create a common information warehouse and tools for all HLS organizations. This technology can be transitioned to the Homeland Security Command and Control Advanced Technology Concept Demonstration

REFERENCES: Current documentation on Information Sharing and Integration:
1) U.S. Army Soldier and Biological Chemical Command, “Military Improved Response Program (MIRP), http://hld.sbccom.army.mil/ip/fs/mirp_fact_sheet.htm, page 2.
2) Title II: Analysis for Homeland Security Act of 2002, Information and Infrastructure Protection, http://www.whitehouse.gov/deptof homeland/analysis/title2.html.
3) National Law Journal, 23 Sept 2002, article: "Creating a Department: Now the Hard Part--Homeland Security in the Second Year", ( page 2, The Report), Dr. David McIntyre, Dep Director of the ANSER Institute for Homeland Security.
4) The October 2002 Hart-Rudman Terrorism Task Force Report, article: "America Still Unprepared- -America Still in Danger, COL Randall J. Larsen, USAF(Ret), Director, ANSER Institute for Homeland Security, pages 19, 22, 32-34.
5) CQ Daily Monitor, 7 Feb 2002, Volume 38, Number 15A, Special Report: Homland Security, $37.7 Billion for Homeland Security, 2% for Information Sharing and Technology, page 1, 17.
6) Information Sharing Homeland Defense Training Conference, 25 Feb 2003, Market Access International, www.marketaccess.org/event_hd_info_sharing.asp

KEYWORDS: Objective Force; FCS; Homeland Security; data base; information system; information management, knowledge portal

A03-090 TITLE: <u>Techniques for Unconventional Terrain Navigation</u>

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Design and build a small, portable and mobil scanning system that can obtain spatial measurements within buildings, caves, tunnels, sewer systems, etc., to be used by dismounted warfighters as part of the Objective

Force Warrior system.

DESCRIPTION: This device must be able to scan large room size areas within seconds. Data collected will provide centimeter resolution or better. During operation, data will be uploaded to a processing station for use by modeling software to produce 2D floor plans and 3D models of the scanned area. The modeling software must be interoperable with planned C2 systems utilizing the DaVinci architecture based on XML technology. The device must be able to traverse the terrain expected in a complex urban or subterranean environment. Stealthy operation is essential to minimize detection of itself and the soldiers that will be operating it. Auto navigation is desired, but various control options, such as voice, keyboard, mouse or joystick, will be considered. Interfaces and data types must meet existing Army standards for transmission, storage and processing on a Windows based computing platform. This system will directly support the Objective Force Warrior and will have data feeds to support planning systems utilized by the Future Combat System.

PHASE I: Develop overall system design, including specification of scanner technology, mapping and modeling algorithms, interfaces, and operating procedures.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL USE APPLICATIONS: Commercial applications would be extensive, including rescue operations, security operations, monitoring hazardous conditions, mapping dangerous areas (such as access ways and spaces where people might be trapped in collapsed buildings or tunnels), and creating floor plans for new or existing construction.

REFERENCES:
1) Borghese, Ferrigno, et al.; Autoscan: A Flexible and Portable 3D Scanner, IEEE Computer Graphics, May-June 1998 (Vol. 18, No. 3).

KEYWORDS: Scanner, navigation, measurement, mapping, modeling, 2D, 3D, urban terrain, Objective Force Warrior

A03-091 TITLE: Command and Control Metrics

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO STRI, PM WARSIM

OBJECTIVE: Command and control is a cognitive process which allows a commander to make decisions about the current situation on the battlefield. Quality assessment of command and control systems continues to be a challenge. Presently assessments of this cognitive process are centered on measures of effectiveness or measures of performance which are subjective and inherently lack a clear ability to quantify these measures. There are questions as to which metrics are appropriate for such a cognitive process as command and control of the battlefield. This is the objective of this research effort, to better define what metrics are appropriate for the command and control process and to provide some insight as to how to extract these metrics from a battlefield architecture.

DESCRIPTION: At present assessment of command and control systems is expressed in terms of measures of effectiveness or measures of performance. When more quantifiable metrics are desired these tend to gravitate towards communications based metrics which give little insight into truly assessing the cognitive process which takes place while a battle occurs. More globally, the issue of command and control metrics not only applies to the cognitive command and control process which takes place in exercises or in actual military missions but also is applicable to the laboratory environment where simulations, stimulations, and emulations are utilized for the design, development and enhancement of existing and new command and control systems for the armed forces. As the Army moves forward towards the Future Combat System and Objective Force Warrior, the command and control process will become more complex with the infusion of new technologies. It is imperative that the Army further mature its assessment tools and capabilities to ensure an accurate valid assessment, as well as understand the architectural concepts which can help facilitate this assessment. Understanding these metrics and the architectures which facilitate their measurement will assist in development and experimentation of C2 systems both in live and virtual domains.

PHASE I: Investigate current cognitive assessment tools and techniques (i.e., including MOE's and MOPs). Investigate current metric tools and a perform a crosswalk of the metrics provided by the tool, the computing platform and operating system required to use the tool and any architecturally unique requirements which enable the tools use. The results of this phase will be a conceptual design for a tool set and architecture based on the R&D and analysis conducted during this phase.

PHASE II: Leverage or develop assessment tools and strategies which focus and address C4ISR architectural implications, or how does a particular C4ISR architecture lend itself towards extracting appropriate command and control metrics. Also it can work in the reverse, what command and control metrics will not be able to be extracted from a particular C4ISR architecture. The initial assessment of the command and control process will result in a set of metrics within a C4ISR architecture applicable to military exercises and events. As this initial set of metrics matures it will focus on improving the command and control process both in the near term and for the Future Combat System and Objective Force. These metrics will be included in an architectural evaluation tool implementing the phase 1 conceptual design in a prototype build which will facilitate the analysis of metrics relative to a proposed command and control architecture relevant to the Objective Force and Future Combat System. This tool will be developed for the Windows environment and will be expandable to evaluate metrics for other domains (ie Communications, ISR).

PHASE III: Command and Control metrics will provide capability to manage, create, and evaluate doctrine and training. This will be critical to homeland security where doctrine, information management techniques and cross-training between civil and military are in their initial concept stages to define how it will be done. Command and control metrics suitable for measuring the cognitive command and control process whether the impetus is live or virtual will be used in military and HLS events and exercises to evaluate the effectiveness of our command and control processes both here and abroad. The maturity and commercialization of this tool will enable it to be utilized or adapted to analyze proposed architectures for law enforcement, air traffic control and homeland security initiatives.

REFERENCES:
1) Hendler, J. (2001). Agent Based Computing for Autonomous Intelligent Software. The Dod Software Tech News, STN Vol. 4. No. 4. October 2001 p2.
2) Cooper, Clive. (2001). Complexity in C3I Systems. Department of Computer Science, University College Australian Defense Force Academy, Camberra A.C.T 2600. Available on the WWW at http://www.csu.edu.au/ci/vol01/cooper01.html February 6, 2002.
3) Solso, Robert (1988). Decision Making: Cognitive Psychology, Second Edition. Boston, London, Sydney, Toronto: Allyn and Bacon, Inc.
4) Clark, T., Moon, T. (unknown date). Assessing the Military Worth of C4ISR Information. Proceedings from the 7th International Command and Control Research Technology Symposium.
5) Wheatley, G. (2002). Analysis of Metrics Utilized in US Joint Experimentation of Future Command and Control Concepts. Proceedings from 2002 Command and Control Research Technology Symposium.
6) Goodman, I. (1999). A Decision-Aid for Nodes in Command and Control Systems Based on Cognitive Probability Logic. Office of Naval Research, In-House Impendent Research Program. SCC-SD, under FY99 IRT Project No. ZU58.

KEYWORDS: command and control, metrics, decisions, complexity

A03-092 TITLE: <u>Advanced Monostatic and Bistatic Azimuth Estimation Techniques</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO IEWS PM SW

OBJECTIVE: To develop and demonstrate monostatic, bistatic, and multilateration angle estimation techniques for Ultra High Frequency (UHF)Ground Moving Target Indicator (GMTI) radar.

DESCRIPTION: The Army is interested in developing a low frequency (UHF Band) GMTI radar to be flown on a rotary wing air vehicle. Current monostatic and bistatic techniques produce relatively large azimuthal error ellipses due to limited available aperture. This large error prohibits accurate targeting from being achieved and causes inaccurate tracks to be established. Future weapons systems will not perform as intended with these shortcomings.

The focus of this effort is to develop improved angle estimating techniques to be implemented in any GMTI system or aggregate of systems that requires improved azimuthal accuracies. It is the goal of this effort to determine the optimal balance between the size of the antenna and the number of phase centers, and also to develop an optimal angle estimation algorithm. Issues to be addressed include a clear delineation of the trade-offs available in Direction Finding(DF) accuracy vice antenna and algorithm complexity vice required processor hardware.
Foliage penetrating radar systems currently under development in the ARMY would greatly benefit from this work. One of the radar systems under development is a UHF GMTI system intended for use on a rotary wing platform. The nominal size, weight, power, cost and complexity of such a system should be considered as objectives in this algorithm development.

PHASE I: Investigate, analyze and present various innovative approaches to develop improved angle-estimating techniques for use in a UHF GMTI system. Compare predicted monostatic performance with current estimating techniques. Predict bistatic and/or multilateration system performance and compare to current techniques. Documentation and a description of the methods, assumptions, calculations and prototypes gathered and developed under this phase shall be submitted in a report. A proof-of-principle demonstration shall be provided.

PHASE II: Develop, test and demonstrate the angle estimation techniques/prototypes from Phase 1. In this phase, data will be collected using assets provided by the contractor that will demonstrate the utility and performance of the angle estimation algorithm in a suitable environment. The techniques should be fully documented to include all source code and documentation required to maintain/modify it and delivered to the government. A report shall explain the approach, implementation and results of the overall effort.

PHASE III: Angle estimating techniques should be of benefit to commercial applications such as air traffic control, law enforcement, coast guard patrols and homeland defense. All possible commercial uses shall be explored.

REFERENCES:

1) Skolnik, Merrill, Introduction to Radar Systems, McGraw-Hill Inc, New York, NY
2) Barton, David, Modern Radar Systems Analysis, Artech House, Norwood, MA,1998
3) Mathanson, Fred, Radar Design Principles, Scitech Publishing Inc., Mendham, NJ
4) Skolnik, Merrill, Radar Handbook, McGraw-Hill Inc, New York, NY


KEYWORDS: Monostatic, Bistatic, Angle estimation, Foliage Penetration, FOPEN, UHF,GMTI,FORESTER, FCS

A03-093 TITLE: Video-Moving Target Indicator (MTI) Trackers for Multiple Targets

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Distributed Common Ground System - Army

OBJECTIVE: The objective of the Video-MTI Trackers for Multiple Targets SBIR is to develop the algorithms and methodologies necessary to extract multiple moving objects/targets out of video/imagery data, establish individual tracks for each and maintain those tracks over multiple image frames. The goal of this effort is to develop an accurate multiple target tracking algorithm for video-MTI. The key issues to be addressed are accurate location and tracking of multiple moving targets, elimination of false targets, and Near-Real Time track processing/reporting.

PHASE I: It has been demonstrated that a moving target can be detected using video/imagery. Phase I will define the issues and methodologies necessary to detect, correlate and track multiple targets within the same image scene. Proper alignment/registration of each frame will be addressed. The impact of time delays between frames on correlating and tracking targets along with accuracy will be investigated. A tracker design will be developed. Phase I will demonstrate detection of multiple targets within the same image scene.

PHASE II: Will develop the tracker and demonstrate its performance. Performance metrics and design issues for the tracker will be obtained. Phase II will address the impact of image complexity on performance and time-critical targeting. Transition plans will be developed to outline Operational utility and Technical execution of a Video-MTI module in a Fielded System. Near-Real Time automated processing algorithm will be developed.

PHASE III: Will integrate the Video-MTI tracker algorithm into a fielded system to assess the performance issues, operator interface and Tactical requirements. Modifications to the algorithms will be made, documented and tested. Final performance and functional documentation will be developed.
Commercial applications will be investigated. It is envisioned that Video-MTI can be utilized in Passive Surveillance systems for Intrusion Detection, Traffic Management and Homeland Security.

REFERENCES:
1) Fishbein, W., Graveline, S.W., Rittenbach, O.E. (1978) "Clutter Attenuation Analysis"; Reprinted in MTI Radar, Schleher, D.C. (Ed); Boston, Ma: Artech House, 1978.
2) Schleher, D.C. (1991) "MTI and Pulsed Doppler Radar"; Boston, Ma: Artech house, 1991
3) Antony, R.T., VGS, Inc., Fairfax, Va "Beyond Level 1 Fusion: Issues and Recommendations", presented at 2002 Military Sensing Symposia National Symposium on Sensor & Data Fusion 13-15 August 2002 at SPAWARSYSCEN-SD, San Diego, Ca.

KEYWORDS: Imagery, Video, MTI, Tracker algorithms, Track Processing, Accurate location, False targets

A03-094 TITLE: Knowledge Engineering Environment for Army Intelligence Analysis and Interpretation

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Intelligence and Effects (PM IE), PEO IEWS PMSW

OBJECTIVE: Develop a knowledge engineering environment enabling distributed teams of subject matter experts in Army intelligence analysis to develop knowledge bases directly and easily without knowledge engineers serving as intermediaries. Use this software environment to develop a real/realistic knowledge-intensive intelligence analysis application for use in Future Combat System operations. Demonstrate and assess the utility of this software environment for building applications that result in increased accuracy and speed in processing intelligence reports.

DESCRIPTION: Many complex battlespace problems the Army faces are handled by subject matter experts (SMEs) such as Army intelligence analysts. For many of the problems in intelligence analysis and interpretation, there are no known algorithmic solutions. This implies that developing computational solutions (automation) to these problems will require encoding the expertise of the analysts within automated systems. However, the process of eliciting, interpreting, implementing and validating problem-solving knowledge from SMEs represents a serious bottleneck in the development of knowledge-intensive systems. The bottleneck has multiple causes. First, the tools in commercial software environments that support this process require artificial-intelligence specialists in order to use them. Second, the tools are somewhat generic in nature in that they are not tailored to handle the knowledge representation and inferencing requirements of specific classes of problems such as intelligence analysis. Third, cognitive psychologists typically are needed to do the knowledge elicitation as well as cognitive and computational model development.

Consequently, the process for building knowledge-intensive systems is extremely slow and very expensive. To overcome the technological limitations and to avoid the requirement for technical personnel as intermediaries, what is needed are automated environments that will provide the support necessary to allow SMEs to construct knowledge-intensive systems directly and easily.

Today, and in the anticipated Future Combat System battlespace, the sheer volume of information to be analyzed and interpreted far exceeds the cognitive capacities of human analysts to process it. If analysts could directly construct knowledge-intensive systems that encode their expertise, there should be a dramatic improvement in the volume of information that can be analyzed. Knowledge-intensive systems could be developed a priori in the context of different anticipated METT-T (mission, enemy, terrain, troops, and time available) situations, and there would be a greater likelihood of modifying such systems (or developing new sub-systems) within a dynamic battlespace context.

DARPA has funded two sequential programs of research and development targeted at the general problems of knowledge engineering (KE) discussed above. The current program, Rapid Knowledge Formation (RKF), is beginning to show progress. However, significant work remains.

The goal of the research proposed here is to investigate and develop automated environments and methods to address the problems above, but must focus specifically on problems and tasks in intelligence analysis and interpretation; these problems are sometimes referred to as problems of data fusion. The research should result in an automated environment that will provide a basis for Army intelligence analysts (alone, and in distributed teams) to directly construct knowledge-intensive systems for some of the critical problems in analysis and interpretation that are central to their responsibilities. Note that this project would also address some of the problems associated with the widespread loss of Army corporate expertise in intelligence analysis resulting when analysts separate from service. This expertise takes years to establish and is costly to replace.

Example potential commercial (dual-use) applications include Homeland Security (intelligence analysis for non-military government agencies such as the U.S. Coast Guard, the INS, and the Federal Emergency Management Agency), as well as analysis and interpretation of data used in medical diagnosis.

PHASE I: Assess, and report on, the state-of-the-art in KE environments. The principal focus will be DARPA's RKF Program. Develop an understanding of critical intelligence analysis and interpretation problems and tasks performed by Army analysts. The understanding will be demonstrated via development of cognitive models of these mental tasks. Based on this understanding, identify the apparent utility as well as limitations of the state-of-the-art KE environments for these tasks. 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 the focus for research and technology development. Provide theoretical and empirical evidence to support the recommended approaches. Select candidate applications for this technology in the commercial (dual-use) sector.

PHASE II: Develop a prototype KE environment targeted at a small set of the critical intelligence analysis and interpretation tasks. Demonstrate the capability of the prototype to develop real/realistic knowledge-intensive systems for these tasks. Design a scientifically sound method (metrics, experiment design, etc.) to evaluate the efficiency and operational effectiveness of the prototype. Conduct experiments to provide an empirical basis for the evaluation. 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.

PHASE III: The technologies developed in Phase II that show promise will be transitioned to Phase III. The highest priority application area is Army Intelligence Preparation of the Battlefield. Example commercial (dual-use) applications include: information/intelligence analysis for non-military government agencies such as the U.S. Coast Guard, the INS, and the Federal Emergency Management Agency, or data fusion supporting diagnosis in internal medicine.

REFERENCES:
1) www.ksl.stanford.edu/projects/RKF/
2)www.cs.utexas.edu/users/mfkb/RKF/

KEYWORDS: knowledge engineering, intelligence analysis, intelligence interpretation, information overload, data fusion

A03-095 TITLE: See Thru the Wall Technologies

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO IEWS

OBJECTIVE: To develop handheld and vehicle mounted see-thru-the-wall capability through the use of infrasound technology.

DESCRIPTION: The Army has a need for a See-Thru-the-Wall capability both handheld and vehicle mounted. All technologies will be considered, however, infrasound will be given preference. Current technologies are limited and not mobile in nature. Infrasound technologies presents a method to overcome the limiting nature of other technologies. The use of infrasound, the technical challenges, the development of infrasound transmitters, receivers, antennas, algorithms for identification of people moving or stationary are covered under this topic. This is a key element for the Future Combat System (FCS) and is spelled out in the FCS Operational Requirements Document (ORD). The amount of power, size, and weight associated with the ability to penetrate walls of various composition and thickness are also of interest under this topic area. Ground work has been done by Department of Energy in this area with relation to location of objects and faults in the earth. Medical field research has revealed the advantages of infrasound as a sensing device and also as a potential non-lethal weapon capability. Both aspects of infrasound technology, sensing and non-lethal weapon, are of interest under this Topic Area.

PHASE I: Investigation of underlying technology as applied to see-thru-the-wall applications and non-lethal weapons applications for infrasound technology. The Phase I will determine the size, weight, power, component technology, and standoff capability achievable based on the limiting physics.

PHASE II: A prototype system will be built for field testing against the Intelligence and Information Warfare Directorate Sense-thru-the-wall test facility and at the Mounted Maneuver Battle Lab field test facility. Transition planning to FCS will occur under this phase also. The ability of the infrasound sensor to operate on-the-move, handheld and vehicle mounted will be evaluated and tested. The ability of infrasound to act as a non-lethal weapon will be demonstrated during Phase II.

PHASE III: Transition of this SBIR into a Phase III will consist of transition to the Army FCS program, the Prophet program and to commercial users such as police, fire departments, immigration and naturalization service, and industrial security of private corporations. The transition potential to military and commercial usage is considered great.

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2) Wayne DeVoe, Jul 2002, ENSCO, Inc. “Compact Infrasound Sensor”
3) E.E. Shpilrain, Feb 2002, Institute for Higher Temperature RAS “Distribute Power Problems-Opportunities and Challenge”, Moscow
4) E.C. Goodliffe, Greater London Council, Jan 2001, “Low Frequency and Infrasound”, ASIN Ref: 0716810484.
5) Valentina N. Tabalevich, Springer Verlag “Microseismic and Infrasound Waves (Research Reports in Physics), Jul 92, ASIN Ref: 0387532935

KEYWORDS: Infrasound, sensors, non-lethal weapons, receivers, transmitters, antennas, size, weight, power, on-the-move, handheld, vehicle mounted.

A03-096 TITLE: Perimeter Detection System

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO IEWS PM SW

OBJECTIVE: Develop a passive, unobtrusive, undetectable perimeter detection system.

DESCRIPTION: Many types of perimeter detection systems work well but are detectable and therefore able to be defeated to allow intrusion to occur. Such systems may be detected visually (not easy to hide) or by other means (detection of RF links, thermal signature, etc.). It is desirable for the perimeter detection system to be inherently small and easily hidden, have a very low thermal signature, and to relay the detections to the system console without means of an RF link. These characteristics are well suited to fiber optic technology, and in particular to perhaps a series of sensors integrated along a fiber optic cable that could be laid along the perimeter and then back to the system console. The fiber can readily be covered with leaves, soil, snow, etc. A key issue for such a system would then be the development and demonstration of sensor technologies that are compatible with the fiber optic string. Under this topic, innovations are sought with respect to any relevant sensor modality with an emphasis on practical implementation into a low cost perimeter detection system. As an example of one promising approach, one could consider seismic sensors based on fiber Bragg gratings. These sensors are very sensitive and emit no radiation of any kind. Multiple gratings could be formed in the same fiber, and interrogated separately using wavelength division multiplexing techniques. This would enable the string of sensors to perform direction finding of potential intrusions. Such a sensor would be ideal not only to protect command posts of military units, but also would be ideal in a homeland defense application to protect high value assets such as nuclear power plants. While the example given here is based on fiber-optics, any innovative and effective technological alternatives are sought.

PHASE I: Design a passive, unobtrusive, undetectable perimeter detection system using an optical fiber sensor-string or other appropriate technologies. Identify relevant sensor approaches and anticipated system performance. If possible, demonstrate a perimeter detection system using a loop of a few meters with a low number of sensors to show proof of concept. System concepts should provide the capability to interrogate individual sensors within the loop, and some capability for coarse direction finding and/or geo-location based on time difference of arrival (TDOA) or other multi-sensor techniques.

PHASE II: Prototype a perimeter detection system of sufficient size to cover a large encampment. Develop algorithms and computer software for data acquisition/analysis to perform direction finding and geo-location of intruders.

Phase III: Develop commercialization strategies for related products with both military and civilian applications, such as protection of valued assets, such as airports, water supplies, regular power plants, private homes and securing of encampment.

REFERENCES:

KEYWORDS: fiber optics, fiber bragg gratings, homeland defense

A03-097 TITLE: All Terrain Combat Identification

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Target ID and Meterological Systems

OBJECTIVE: Develop an innovative, robust and affordable Combat Identification system that will operate under all terrains and conditions. This system must be applicable to the objective force and future combat initiatives.

DESCRIPTION: Joint, Allied and Coalition forces require a robust, all terrain, all weather, day/night combat identification (CID) system. The system must be omni present and operate under a wide range of circumstance, that include but is not limited to: electronic counter measures, and communication with air, ground and space blue assets. It must operate in both the mountain and desert environments, as well as the MOUT (Military Operations in

Urban Terrain) environment. A combat ID system that will work in all environments is essential to modern warfare. The system must work for vehicle, as well as non-vehicle applications. The system must be interoperable with commonly used ID systems. The purpose of this effort is to develop an innovative architecture for a combat ID System. The topic will address practical implementation aspects of physical integration, concept of operation (CONOPS) and operation with other equipment on the applicable platforms. This topic is relevant to the Coalition Combat ID ACTD and STO.

PHASE I: The contractor shall develop an innovative concept for the All Terrain Combat Identification system. The contractor shall perform a feasibility analysis of the design and demonstrate its veracity through analysis, simulation, or other means. This analysis shall include, but not be limited to: size, weight, power, sensors, waveforms, operational and other pertinent issues.

PHASE II: The contractor will develop, prototype and demonstrate the concept that was developed in Phase I. The contractor shall construct a software model to predict and analyze the detailed performance of the system. The contractor shall deliver a prototype of the concept developed in Phase I. The contractor shall demonstrate the system and compare the measured sensor performance against expected sensor performance values resulting from the phase I modeling efforts.

PHASE III: Technologies for friendly identification have a wide variety of application to commercial 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. This technology could be demonstrated as part of the Coalition Combat ID ACTD.

REFERENCES:
1) Coalition Combat Identification Advanced Concepts Technology Demonstration (CCID ACTD), June 2002, CISC 2002, Pete Glikerdas, Gerardo J. Melendez, PhD, MAJ(P) Kirk T. Allen, & John G. Lalonde.
2) COMBAT IDENTIFICATION CONCEPTS AND CAPABILTIES FOR THE FUTURE ARMY, June 2002, CISC 2002, Gerardo J. Melendez, Ph.D. & Panagiotis (Pete) Glikerdas.

KEYWORDS: fratricide, combat identification, sensors, radio frequency (RF) ,MOUT, all terrain

A03-098 TITLE: Wind Blown Clutter Reduction to Improve Ultra High Frequency (UHF) Moving Target Indicator (MTI) Performance

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO IEWS, PM SW

OBJECTIVE: To develop and demonstrate an innovative technique to reduce wind blown clutter effects on the performance of UHF band Ground Moving Target Indicator (GMTI) systems.

DESCRIPTION: The Army is considering the use of a high altitude, low frequency (UHF Band) GMTI radar to detect very slowly moving targets under the cover of foliage. The system would be flown on a rotary wing aircraft that will hover, or move very slowly, over the targeted surveillance area and also at standoff distances. The system would provide persistent surveillance from a fixed location and would use coherent integration intervals that are much longer than for conventional MTI radars.
Wind blown tree clutter is known to be a major problem for this type of system. It is the goal of this effort to develop innovative dynamic cancellation/mitigation techniques for improving detection performance and reducing false alarms in the presence of wind blown tree clutter.

PHASE I: Investigate, analyze and present various innovative approaches to develop a dynamic clutter canceling technique/prototype to reduce the effects of wind blown tree clutter on low frequency, helicopter-borne GMTI radar. Compare the expected performance with that of the current suppression techniques. A proof of principle demonstration will be provided if feasible. Results of analysis shall be provided in a report at the end of the efforts.

PHASE II: Fully develop, test and demonstrate the dynamic clutter suppression algorithms/prototype from phase 1. For this phase, data that will be provided by the Government will be used to demonstrate the utility of the clutter suppression algorithm in a suitable environment. The suppression techniques should be fully documented, to include all source code and documentation required to maintain/modify them and provided as a deliverable. A report shall explain the approach, implementation and results of the overall effort.

PHASE III: Modify the clutter suppression technique if/as necessary for application in a variety of other military and civilian roles. Applications to homeland defense such as perimeter and area security, and law enforcement applications such as apprehension of fleeing suspects should be explored.

REFERENCES:
1) Billingsley, Impact of Clutter Spectra on Radar Performance Prediction, IEEE Trans. On Aerospace and Electronic Systems, vol.37, no.3, pp1022-1036, July 2001
2) Billingsley, Low-Angle Radar Land Clutter: Measurements and Empirical Models, Science Tech. Pub. Norwich, N.Y., 2001

KEYWORDS: GMTI, FOPEN, Foliage Penetration, Clutter Suppression

A03-099 TITLE: Selective Localized Global Positioning System (GPS) Denial

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: Develop the algorithms/software for a tailored denial system (ground platform) to prevent the selective operation of GPS at a target of interest. This is to be accomplished by exploiting coded jamming such that coordinated interference canceling techniques can suppress interference in the GPS band.

DESCRIPTION: The topic investigates techniques to provide both local and extended area denial of GPS while allowing friendly forces in the same region to continue to use GPS. The specific technological innovations sought under this topic include waveform designs, coordinated multi-platform distributed transmission of jamming waveforms, etc. such that jamming is achieved effectively on target and electronic fratricide is avoided among friendly forces. GPS is a significant factor in tactical and strategic planning, where precision navigation and timing is valuable to the military for information in a combat environment to coordinate forces. GPS precision attack capability for precision delivery is a part of modern weapons and their firing platforms. The accessibility of civilian GPS receivers and the uninterrupted GPS signal allow an unsophisticated adversary to apply precision navigation, and precision attack weapons and philosophies against US forces and installations. It is desirable to protect our own GPS capability, while at the same time preventing an adversary from using their GPS. A near term solution is needed to selectively deny GPS. The intrinsic vulnerability of GPS to localized jamming allows friendly and unfriendly forces to easily negate GPS in a battle area. This topic addresses the tailored jamming and receiver segments for selective denial. The topic examines the requirements and limits of a tailored GPS denial system against an adversary. The desired deployment platform is the High Mobility Multipurpose Wheeled Vehicle (HMMWV). The system shall incorporate a flexible power source capability to operate from self-contained batteries, line voltage, vehicle power, or military generators.

PHASE I: Conduct a study of feasibility, effectiveness, and cost for a selective localized denial of service system for GPS. Develop the requirements for tailored jamming and receiving segments.

PHASE II: Design, build and test a prototype of the selective denial system for laboratory and anechoic chamber testing and field demonstration. The unit should be suitable for field operation and evaluation.

PHASE III: Potential military applications exploit the jamming of civilian GPS frequencies while maintaining military GPS frequencies. Dual use opportunities utilize the localized denial capability to limit the jamming effects to a specific area. This has direct applications in Homeland Security operations where it is desirable to secure friendly use of GPS while eliminating adversary use of GPS. Homeland Security applications of this technology would maintain GPS use for friendly situational awareness while blocking the use of GPS by our adversaries.

REFERENCES:
1) Future Combat Systems Operational Requirements Document: 4.1.1.3.1.2 FCS systems must accomplish position/navigation (horizontal and vertical) to a one meter Spherical Error Probable (SEP) with a Low Probability of Detection/Interception and in the presence of electronic jamming. (Objective) [ORD 1159]
2) References available at http://www.darpa.mil/fcs

KEYWORDS: Global Positioning System, Jamming, Denial

A03-100 TITLE: High Speed, High Power, Electronically Tuned Components

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO IEWS, PM SW

OBJECTIVE: Develop electronically tunable components capable of being varied at high speed and operated in high-power amplifiers and tuners at frequencies from 1.5 to 3000 MHz for use in a variety of military and civilian systems.

DESCRIPTION: A variety of military systems utilize frequencies from 1.5 MHz to 3 GHz, and many must be frequency-agile. Military applications include communication systems and electronic collection and attack systems such as the Joint Tactical Radio System (JTRS) and subsystems for use in the Future Combat System. Civilian applications include commercial TV/radio/cellular/PCS communications, RF heating and lighting, plasma generation, and medical applications such as x-ray and magnetic-resonance imaging (MRI).

Currently available technology for power amplifiers (PAs), matching networks, and antennas does not satisfy the needs of evolving military requirements. Today's broadband, high-efficiency PAs are limited to HF and lower VHF. PAs for UHF and higher frequencies are either restricted to narrow bandwidths or characterized by distributed amplification, poor efficiency and large physical size. Antennas are either subject to limited frequency range or low efficiency and gain.

The possibility of an electronically tuned high-efficiency PA has been demonstrated. However, implementation is hindered by lack of suitable components. Tuning devices based on varactor diodes, ceramics such as barrium strontium titanate (BST), and Micro Electro-Mechanical Switches (MEMs) have been demonstrated. However, such devices made to date are capable of handling only relatively low power. Suitable tuning devices need to be capable of handling 100 W or more and tuning over a range of at least 3:1 and preferably 5:1.

The availability of electronically tunable components will make possible a variety of improvements, including higher efficiency, lower weight,smaller size, reduced prime power requirements, extended battery life, increases in operational time, and greater frequency agility. The increased operating bandwidth will also reduce the number of different radios, jammers and antennas required.

PHASE I: Investigate techniques for achieving program objectives. Test critical design concepts through simulation or experimentation. Prepare conceptual component designs.

PHASE II: Design, fabricate, and test prototype components. Demonstrate components in prototype filter or amplifier system.

PHASE III: The generation of RF power and the need for frequency agility goes beyond military requirements and includes; commercial TV/radio/cellular/PCS communications, RF heating and lighting, plasma generation, and medical applications such as x-ray and magnetic-resonance imaging (MRI).

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1) H. Zirath and D. B. Rutledge, "An LDMOS VHF class-E power amplifier using high-Q noval variable inductor," IEEE Trans. Microwave Theory Tech., vol. 47, no. 12, pp. 2534-2538, Dec. 1999.
2) F.H. Raab, B.E. Sigmon, R.G. Myers and R.M. Jackson, "L-band transmitter using Kahn EER technique," IEEE Trans. Microwave Theory Tech., pt. 2, vol. 46, no. 12, pp.2220-2225, Dec. 1998.
3) F.H. Raab, "Electronically tunable class-E power amplifier," Int. Microwave Symp. Digest, Phoenix, AZ, vol.3, pp. 1513-1516, May 20-25, 2001.
4) R.J. Richards and H.J. De Los Santos, "MEMS for RF/microwave wireless applications: The next wave," Microwave J., vol. 44, no. 3, pp. 20-41, March 2001.
5) B. Kapilevich and R. Lukyanets, "Modeling varactor tunable microstrip resonators for wireless applications," Applied Microwave & Wireless, vol. 10, no. 7, pp. 32-44, Sept. 1998.
6) A. Tombak, "Tunable barium strontium titanate thin film capacitors for RF and microwave applications," IEEE Microwave and Wireless Components Letters, vol. 12, no. 1, Jan. 2002.


KEYWORDS: radio frequency, amplifiers, transmitters, communications, bandwidth, tuning, MEMs, BST, varactor, capacitor, inductor semi-conductor.

A03-101 TITLE: Low Probability of Intercept/Low Probability of Detection (LPI/LPD) and Radio Frequency Interference (RFI) Mitigation Techniques

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO IEWS , PM SW

OBJECTIVE: To study, develop and evaluate methods to reduce Radio Frequency Interference (RFI) and lower the probability of intercepting Ultra High Frequency (UHF) Moving Target Indicator (MTI) radar systems.

DESCRIPTION: The Army is working to develop a UHF MTI radar to be flown on a rotary wing air vehicle. With the large amount of electromagnetic clutter in the UHF spectrum, RFI is a major problem for this type of system. The Army is interested in investigating ways to reduce the interference caused by a UHF MTI radar system on other friendly systems. The Army is also interested in investigating ways to reduce the RFI effects on the UHF system currently under development.
Information and system security is always of the highest importance. The most effective way to keep a system secure is to deny the enemy's ability to detect it in the first place. Therefore the army is interested in researching and developing Low Probability of Intercept/Low Probability of Detection (LPI/LPD) waveforms. The goal of this effort is to develop new and innovative RFI and LPI/LPD mitigation waveforms.

PHASE I: Investigate, analyze and present various approaches to develop and improve current RFI reduction and LPI technologies. Predicted results should be compared to current methods and show improvement. Documentation, assumptions, calculations and results will be presented in the form of a report at the conclusion of the efforts.

PHASE II: Develop, test and demonstrate the LPI/LPD and RFI reduction waveforms. This phase will include data collections to support previously conducted analysis. Data should be collected in a suitable environment, which should include a variety of RFI sources and various Signal Intelligence technologies. A report will be presented at the conclusion of the efforts and include all test plans, results, techniques and methods used in the new techniques.

PHASE III: Apply RFI reduction waveforms to benefit commercial applications and to help mitigate general broadcast interference. The waveform should be able to lower the interference caused by television broadcasts, amateur radios and other transmitters that are present in the UHF band.

REFERENCES:
1) Smith, L.E, 1994, “Modulation Choices for LPI/LPD communication systems”, Tactical Communications Conference, 1994., Fort Wayne, Indiana
2) Turner, L., 1991, “The Evolution of featureless waveforms for LPI communications”, Aerospace and Electronics Conference, 1991, Dayton, Ohio
3) Adamy, David, 2001, EW 101 A First Course in Electronic Warfare, Artech House Inc, Norwood, MA

KEYWORDS: LPI, RFI, FOPEN, Foliage Penetration, GMTI

A03-102 TITLE: Global Positioning System (GPS) Interference Electronic Support Measure (ESM) Payload for Unmanned Aerial Vehicles (UAVs)

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Aerial Common Sensor

OBJECTIVE: Develop a small, modular, low cost and low power Electronic Support Measure (ESM) sensor payload for UAVs to detect and locate sources of GPS interference.

DESCRIPTION: The topic looks at alternate techniques to accurately locate GPS jammers from UAVs while maintaining navigation and flight integrity for the mission. The modern battlefield relies on GPS for affordable navigation accuracy and precision timing. The GPS signal can be susceptible to interference, both intentional and unintentional. One difficulty in locating a GPS jammer using a UAV is the possibility that the sensor platform itself depends on GPS for navigation, and is vulnerable to jamming. The topic examines concepts to compute angle-of-arrival, elevation and bearing to GPS interference, and localize the source of interference using a small sensor payload. Small systems can process spatial nulls using non-developmental item (NDI) spatial antijam circuitry to resolve control settings in the null process into radio direction finding (RDF) for angle-of-arrival, elevation and bearing. NDI systems programmed for the task should be dual use having small antennas suited for UAV installation to resolve RDF angle and suppress jamming. Direction information produced can support Radio Frequency Interference (RFI) location using UAVs equipped to fly at the interference or by using high-resolution line-of-bearing information to interference for triangulation. Location accuracy may depend on range to the source and integration time. Airborne DF operations can be effectively conducted using small UAVs flying at low speeds and altitudes, typically flying straight-and-level in searching, or circles about a suspected RFI source. The UAV will enable the sensor to fly close to the source (where most jamming sources are on the ground and stationary) and provide sufficient time to interpret measurements. The topic shall look at DF systems that can estimate RFI source azimuth and elevation angles with respect to the airframe. The DF system shall be capable of measuring source azimuth relative to heading, and UAV location from fusion with alternate navigation techniques, which may use GPS pseudolites, inertial units, Loran, TACAN, Link-16, etc. Scenarios can include: flying the UAV in the direction of the jamming source azimuth, pointed toward the source, over flying the source and monitoring elevation-angle, etc. For cases where jamming is intermittent, sources may be located by triangulation from the baseline flight path. The topic shall investigate the feasibility and design of concepts for UAV sensors to detect and locate GPS jamming using synthetic aperture techniques and cooperative detection and location techniques. The topic shall integrate ESM and protection functions.

PHASE I: Conduct a study of feasibility, accuracy and cost for a small UAV sensor package and antenna system to locate sources of GPS interference. Examine alternate DF and navigation fusion approaches. Develop the requirements for the sensor system. Coordinate the concept with similar US Air Force, US Navy and other agency requirements.

PHASE II: Design, build and test a prototype of the GPS jamming sensor system. The unit should be suitable for field operation and evaluation.

PHASE III: Potential military applications include small UAVs such as the Hunter or Predator. Dual use opportunities exist in the civilian sector, especially for the detection and location of interference at the civilian GPS frequency. Documented incidents of unintentional as well as intentional interference events have cost considerable amount of time, money, and resources to resolve.

REFERENCES:
1) Future Combat System of Systems Statement of Required Capabilities, 2 November 2001, SoRC E8: Support counter-reconnaissance effort to blind enemy RSTA through use of obscurants, jamming, signature reduction, deception, disinformation, and pattern avoidance techniques. Employ RSTA to detect and find, then defeat, disrupt or neutralize enemy sensors through security operations.
2) References available at http://www.ausa.org/RAMPnew/Fcs_sorc.pdf.

KEYWORDS: Unmanned Aerial Vehicles, Payload, Global Positioning System, Jamming, Detection, Location

A03-103 TITLE: Low-Loss Synthetic Aperture Radar (SAR) Data Compression

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO IEWS, PM SW

OBJECTIVE: The objective of the Low-Loss SAR Data Compression SBIR is to develop the algorithm and methodology to compress SAR data without significant loss of information. The compression of complex SAR amplitude and phase information will reduce the transmission bandwidth requirements for dissemination of the information. The goal is to obtain good compression ratios while minimizing the loss of critical information from the SAR data. Automated target detection and recognition algorithms require the utilization of the complex SAR data for accurate information extraction. The key issues are near-real-time (NRT) processing, alignment of the compressed data, low-loss / distortion and geo-registering the image after compression.

PHASE I: Will define the problem and alternative approaches/solutions. An analysis and trade-offs of each approach will be conducted. A recommended approach will be selected. Phase I will implement the recommended approach. SAR data compression will be demonstrated and tested. Performance metrics and issues will be obtained and presented.

PHASE II: Will address the impact of image complexity on the compression algorithm's performance. Processing performance will be analyzed to assess the capability for Near-Real-Time execution. Geo-registration of the compressed image concerns and impacts will be addressed. Automatic detection and recognition algorithm impacts will be assessed. Image compression performance versus image quality will be specified.

PHASE III: Will implement a Near-Real-Time Processing algorithm within a fielded system. Operational requirements will be addressed and user interface issues resolved. Modifications to the algorithms and testing will be completed. Functional and performance specifications will be developed.
Commercial applications of the Compression algorithms can be utilized in Web-based Video transmission, Geological data collection and analysis, and Surveillance storage systems.

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KEYWORDS: Image compression, Near-Real-TIme processing, Synthetic Aperture Radar (SAR) data, transmission bandwidth, amplitude and phase information

A03-104 TITLE: Low Cost Three Dimensional Laser Radar Receiver

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a low cost detector/readout electronics array for three dimensional imaging laser radar.

DESCRIPTION: The Army is interested in three-dimensional (3-D) imaging of tactical targets using a short laser pulse (~ one nanosecond or less duration) for active illumination at nominally 1.5 microns wavelength. Needed is a time resolving optical receiver consisting of an array of avalanche photodiode (APD) detectors, or other optical detection technology with internal gain, coupled with the necessary “readout” electronics to complete a demonstration device. Desired is a laser radar receiver that can perform a single pulse acquisition of a 64x64xN, (x,y,R) voxel image of a vehicle for visual or machine recognition. The range (R) dimension of the image might be first and last returns (required) or first and last two returns (desired). The desired maximum depth in the R dimension is 30 meters. Detection methods to improve range accuracy and resolution beyond simple threshold crossing are encouraged. The detector/readout cell pitch (x, y) is desired to be 50 microns or less with a 90% detector area fill factor. The sampling interval (t) is desired to be 0.5 nanoseconds or less. Techniques that do not meet the desired characteristics will be considered if shown to meet the needs of the program.

PHASE I: Conduct study and design efforts to prove the proposed concept is viable.

PHASE II: Construct the receiver and demonstrate and its performance in a field experiment. Perform calculations that predict the performance of a sensor based on the component demonstration.

PHASE III: Develop manufacturing methods for the low cost laser radar receiver. Commercial applications include: building construction, terrain mapping, factory automation, robotics, obstacle avoidance and collision avoidance.

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2) Trussell, C. W.,

KEYWORDS: Laser Radar, Ladar, 3-D Imaging, Sensors

A03-105 TITLE: <u>Optical Components to Reduce Retroreflection from Uncooled Infrared Focal Plane Array</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM-NV/RSTA

OBJECTIVE: Design, build and integrate innovative opto-electronic components that reduce optical cross section of long wavelength IR sensor systems, resulting in improved compact low cost signature management solutions to deny the enemy's ability to detect and engage our forces.

DESCRIPTION: Recent advances in uncooled long wavelength infrared (LWIR) imaging sensors have enabled their use in many military and civilian applications that require smaller size, lighter weight and lower cost than alternative IR technologies. These sensors are now being considered for many Future Combat System platforms to meet target acquisition, navigation and surveillance requirements. These sensors are also being used in the commercial marketplace for surveillance and security applications as well. In military applications, it is very important to manage the signature of sensors without compromising performance. The reflectivity of current uncooled LWIR sensor technology is unacceptably high and compromises their detection by use of search CW lasers. It is highly desirable to reduce the reflectivity of uncooled imaging sensors by use of optical, electronic, imaging or any other innovative techniques that can be practically integrated into the compact sensor system package. For example, the angle of incidence of the incoming radiation may be deviated optically so as to minimize the retroreflection or the incoming image may be modified by use of optical or image processing techniques to make it out of focus and to reimage it for display. In addition, novel optical design concepts that enable more compact LWIR sensors to be developed are encouraged.
The following parameters are provided for consideration in the design phase of a low reflectivity uncooled LWIR sensor: f/# of 1.7, a microbolometer-based FPA of 640x480 pixels of 25mm size with the overall size of 0.48 x 0.64 inches, and the spectral band of 7.8 – 12.2 micrometer. It is desired that the components developed under this SBIR topic include the design flexibility so as to be used with other uncooled IR sensors with similar specifications.

PHASE I: Demonstrate the technical feasibility of the proposed approaches through design and analysis by use of optical, electronic or other innovative techniques. Demonstrate experimentally the feasibility of the design.

PHASE II: Fabricate and evaluate prototype components with the baseline sensor system. Optimize the design, fabricate and integrate the components with the baseline sensor system, and test the integrated sensor system for performance validation. Conduct design analysis so as to adapt it for other IR sensor systems with similar specifications.

PHASE III: DUAL USE APPLICATIONS: Technology thus developed can be used in military and civilian applications where the retro-reflection from the uncooled IR FPAs is undesirable. Potential applications may include medical and astronomical imaging applications.

REFERENCES:
1) “Optics,” by Eugene Hecht and Alfred Zajac, published by Addison-Wesley Publishing Co, Reading, MA.
2) Other books and publications on geometrical optics.
3) “Digital Picture Processing,” by Azriel Rosenfeld and Avinash C. Kak, published by Academic Press, New York, NY.
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5) J. Sonstroem, B. Ahn, “Low Observable Staring Sensors” (U) Proceedings of the 2000 Meeting of the MSS Specialty Group on Passive Sensors, March 2000.
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KEYWORDS: far-infrared sensor, retro-reflection, uncooled, microbolometer,
defocusing, deviation, extended optical depth of field, digital filtering, encoding, decoding, chromatic aberration.

A03-106 TITLE: Uncooled Infrared (IR) Camera with High Resolution Zoom

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The objective of this project is to increase the recognition and identification range by up to 3 times for uncooled infrared cameras.

DESCRIPTION: Uncooled IR cameras using microbolometer arrays have been available for several years. These cameras provide night vision for various applications, including reconnaissance, surveillance and weapons sights. Typical systems utilize a 320x240 microbolometer focal plane array with 15-100 mK NETD performance. Current IR cameras do not provide a high quality zoom feature. Some IR cameras feature digital zoom capability. This generally consists of expanding the imagery from the central 160x120 pixels to cover the entire display. Natural jitter can increase resolution up to 3x.

PHASE I: Demonstrate an IR zoom concept.

PHASE II: Build and demonstrate an actual IR zoom camera and demonstrate up to 3x improvement in resolution.

PHASE III: A zoom IR camera has many commercial applications including security of borders, nuclear power plants,transit systems, bridges and tunnels.

REFERENCES:
1) "Multiframe enhancement of FLIR and infrared seeker images", Barnaby Smith, Defense Science and Technology Organization, Proce. SPIE Vol. 3377, August 1998
2) "Microscan in infrared staring systems", Abraham Friedenberg, Elop Electrooptics Industries Ltd., Optical Engineering 36(06), June 1997
3) "Image Preprocessing in the Infrared", Dean Scribner, et. al, Navel Research Lab., Proc. SPIE Vol. 4028, July 2000
4) "Scene Based Techniques for nonuniformity correction of infrared focal plane arrays", Soph8a Tzimopoulou-Fricke, et. al., University of Reading, Proc. SPIE vol. 3436, Oct. 1998

KEYWORDS: Zoom IR camera

A03-107 TITLE: Landmine Detection

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM - Close Combat Systems

OBJECTIVE: Develop a state-of-the-art technology capable of detecting on-route buried land mines.

DESCRIPTION: The objective is to develop advanced mine detection technologies to provide new or improved mine detection through discrimination and or identification capabilities. Novel concepts and techniques are encouraged. Technologies including, but not limited to, nuclear, ground penetrating radar, infrared, x-ray, electromagnetic, acoustic or other methods may be considered. Proposals that address algorithm development will be accepted, but a specific source of test data must be specified. The effort should be planned with the goal of demonstrating technologies for detection with a near 1.0 Probability of detection (Pd), sub 0.01 false-alarms per square meter at rates of advance appropriate for small ground vehicles. Techniques that are slow but have a very high capability are also of interest as a confirmation sensor. The proposed technologies shall address individual anti-tank (AT) and anti-personnel (AP) mines, whose burial depths can vary from surface laid to 20 cm below the ground surface. Burial depth is defined from the surface of the ground to the top of the target. The landmines will range in size from 4.5 cm to 38 cm (which covers AP to AT mines respectively) in diameter or width. Explosive fill is typically TNT, RDX or PETN. The mines may employ a variety of fuse types, including pressure, tilt rod, magnetic influence, seismic/acoustic and other sensors. The proposed technologies are intended for use in support of a highly mobile force; therefore, rate-of-advance (OP-TEMPO) is an important factor. A remotely controlled or robotic vehicle is the likely host platform. Proposals that only address the platform without including new and innovative sensors are not of interest. Size, weight and power consumption are important factors. The ground clearance of the sensors must be 30 cm. at a minimum. Proposed technology applications should address the development of hardware/software and field exercises to ascertain mine detection capability.

In order to support continuing acoustics research the following topic is of interest: Laser Doppler Vibrometers based on fiber-optic technology to reduce the cost and size, and improve the performance and ruggedness of such sensors. We need to sense ground velocities on the order of micrometers per second (with small displacements, typically a few nanometers) at acoustic frequencies from 50Hz to 1kHz. Since non-specular reflections from widely differing surface types are likely to be very small, the capability of detecting optical returns as weak as possible, but typically –90dB, is necessary. Current versions of LDVs use interferometric (or heterodyne) sensing of the reflected light, with bulk optical components for directing and manipulating the laser beams internal to the sensor head. A fiber-optic approach for implementing the laser, beam-splitter(s), and detector(s) currently would seem to produce the most rugged system, but the technology manufacturer is free to explore alternative designs, keeping in mind that the system must be immune to external vibrations.

PHASE I: This proof of feasibility phase will focus on laboratory and limited field investigation of the novel 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 or representative components for different classes of mines.

PHASE II: The purpose of this phase is to design and fabricate a brassboard data acquisition system and to use this brassboard to experimentally confirm/verify the detection capability under varied conditions. The sensitivity of the mine detection technique to discriminate mines from clutter objects will be determined. Data collections and tests at Army test sites are 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, Pd, Pfalse-alarm and positional accuracy.

PHASE III: This technology has numerous applications in the Army, Navy, humanitarian demining area as well as counter terrorism. This tool could be utilized either in a joint mode with neutralization techniques or independently.

REFERENCES:
Information regarding the current state-of-the-art in countermine technology employing LDV technologies can be obtained through the following conferences:

1) SPIE AeroSense Conference (Detection and Remediation Technologies for Mine and Minelike Targets Session)

in Orlando, FL.; Mine Warfare Conference; and UXO Detection and Remediation Conference. FM 20-32
2) Mine/Countermine Operations is the Army Field Manual which provides technical guidance for conducting mine and countermine operations.
3) Numerous references and links are available through the following sites: Mine Warfare Association - www.minwara.org;
4) BRTRC humanitarian demining website - www.demining.brtrc.com

KEYWORDS: Landmine technologies, mine detection, Laser Doppler Vibrometer

A03-108 TITLE: Off-Route Mine Detection

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Close Combat Systems

OBJECTIVE: Develop a state-of-the-art off-route mine detection technology capable of detecting existing and next generation off-route and side-attack land mines.

DESCRIPTION: The threat to the Army from off-route and side-attack mines has grown significantly in recent years. Side-attack mines are weapons that attack vehicles and personnel from the side as the target passes by. There are numerous side-attack mines in use today by many countries and more are under development. Within a few years, they are expected to have proliferated to every combat environment. These devices have widely varying characteristics and range from large plate charges, such as the TM-83, or fragmentation mines, such as the MON-xxx series, to modifications of shoulder-fired anti-tank rockets, such as the PARM-1, to command-detonated improvised explosive devices (IEDs) that may be concealed in camouflaged coverings. The devices are typically placed at the sides of a route at ranges of up to 200 m. They may be concealed by camouflage or foliage but are not buried. Recent preliminary experiments indicate that radar can be used to detect such targets. The objective of this effort is to develop advanced mine detection techniques to provide new or improved detection of off-route mines through discrimination and or identification capabilities using radar-based technologies. Technologies including, but not limited to, ground penetrating radar, foliage penetrating radar, synthetic aperture processing, and use of various antenna and polarization concepts may be considered. Novel concepts and techniques are encouraged. The characteristics of clutter are considered to be different than those encountered in on-route mine detection. The effort should be planned with the goal of demonstrating technologies for detection with a near 1.0 Probability of detection (Pd), high clutter discrimination and low false-alarm rate at rates of advance appropriate for ground-vehicular platforms. Novel concepts for precise location accuracy of off-route land mines applicable to distances greater than a few meters are of particular interest. Techniques that are slow but have a very high capability may also be of interest as a confirmation sensor. The proposed technologies shall address individual anti-tank and large anti-personnel mines. The landmines have a wide range of sizes and shapes. For example, the MON-200 is cylindrical in shape with a diameter of 434 mm and a depth of 130 mm, while the PARM 1 looks like a shoulder fired rocket set on a tripod. Explosive fill is typically TNT, RDX or PETN but may be other materials, particularly in the case of IEDs. The mines may employ a variety of fuse types, including infra-red sensors, seismic/acoustic sensors and various command detonation techniques. The proposed technologies are intended for use in support of a highly mobile force; therefore, rate-of-advance (OP-TEMPO) is an important factor. The Army's Future Combat System (FCS) family of vehicles are likely host platforms. Solutions requiring dedicated or specialized vehicles are not acceptable. Techniques should lend themselves to modular and bolt-on applications. Size, weight and power consumption are important factors. Proposed technology applications should address development of hardware/software and field exercises to ascertain mine detection capability. This effort will support and leverage ongoing STO programs in Off-Route Mine Detection and Neutralization.

PHASE I: This proof of feasibility phase will focus on laboratory and limited field investigation of the novel off-route mine detection technique(s) as a potential candidate for application as a tactical mine detection system. The sensitivity of the mine detection technique in discriminating mines from clutter objects will be determined. Phase I will include a demonstration to experimentally confirm/verify the lab results and analyses by utilizing a variety of mines and surrogate mines or representative components for different classes of mines.

PHASE II: The purpose of this phase is to design and fabricate a brassboard data acquisition system and to use this brassboard to experimentally confirm/verify the detection capability under varied conditions. Practical application of the technology, including proposed host-platform integration (i.e., on a ground vehicle), will be investigated. Estimates, with supporting data, will be made of size, weight, power requirements, speed, Pd, Pfalse-alarm and positional accuracy.

PHASE III: This technology has numerous applications in the humanitarian demining area as well as counter terrorism. This tool could be utilized either in a joint mode with neutralization techniques or independently.

REFERENCES:
Information regarding the current state-of-the-art in countermine technology can be obtained through the following conferences and other references:
1) SPIE AeroSense Conference (Detection and Remediation Technologies for Mine and Minelike Targets Session) in Orlando, FL.; Mine Warfare Conference; and UXO Detection and Remediation Conference.
2) FM 20-32 - Mine/Countermine Operations is the Army Field Manual which provides technical guidance for conducting mine and countermine operations.
3) Numerous references and links are available through the following sites: Mine Warfare Association - www.minwara.org;
4) BRTRC humanitarian demining website - www.demining.brtrc.com;
5) demoz.org/Society/Issues/War,_Weapons_and_Defense/Landmines;
6) Demining Technology Center (DeTeC) website.

KEYWORDS: Landmine technologies, mine detection, radar, synthetic aperture radar (SAR), ground penetrating radar (GPR), foliage penetrating radar (FOPEN)

A03-109 TITLE: Detection of Non-buried Explosives using Chemical Detecting Technologies

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM-CCS

OBJECTIVE: The objective of this contract would be to design and develop a sensor to effectively detect the presence of explosives in a desired location of high importance. It will need to function as a handheld device as well as a mountable sensor on a robotic platform for the objective force warfighter.

DESCRIPTION: The Army is currently looking for new technologies to chemically detect the presence of explosives. The ability for the Army to have multiple sensing/imaging techniques to create the highest level of intelligence possible during operational modes is of capital importance. First, an example of a sensor would be handheld devices that could be used in covert and overt operations. This device would be able notify the soldier as well as transmit a signal to Army's forces. The sensor will identify the concentration level of explosive material in a specific direction and range. In a second example, the sensor/sensors could be mounted on a robotical platform and have the ability to function ahead of the soldier to create standoff proximity. Naturally, in all instances, the lightweight sensor must function in real-time and have sensor fusion capabilities with other detection technologies such as, infrared, acoustics, etc.

Chemical/biological/olfactory sensor development to detect explosives is a new area of interest. Also, it is of the high importance that the sensor design should be able to decipher between types of explosives. The sensor will need the capability to detect explosives through materials such as, plastic, metal, and wood, as well as through walls, casings, luggage, and boxes, or any non-buried ordnance.

The sensor should be able to operate under all environmental and climate conditions. The sensor/sensors would be particularly useful in urban warfare, where warfighters would need to secure buildings and therefore be required to locate and compromise all booby-trap type ordnances. Within the matter of seconds, the sensors should be able to identify explosive material at a specific range.

PHASE I: The proof of feasibility phase will focus on laboratory experiments investigating signature behavior of explosives and extraction of vapor molecules and/or particulate matter within the vapor. Discrimination between explosive related chemicals (ERCs) will be tested.

PHASE II: The purpose of this phase is to test and fabricate a sensor in the laboratory and confirm/verify detection capability under various environmental conditions. The sensitivity, selectivity, and range capability of the sensor will be determined. Optimization will also be a task as well as development of a prototype sensor that will be employed for use in blind-test experiments. Practical application of this technology will be investigated to transition it to the commercialization phase.

PHASE III: This technology has numerous applications in the objective force as well as counter terrorism. This tool could be utilized either in a joint mode with identification/imaging techniques or independently. Airport screening applications of this device could be used similar to that of the current metal detector.

REFERENCES:
1) Jenkins, T.F., Marianne E. Walsh, Paul H. Miyares, Jessica A. Kopczynski, Thomas A. Ranney, Vivian George, Judith C. Pennington, and Thomas E. Berry, Jr. (2000). "Analysis of Explosives-Related Chemical Signatures in Soil Samples Collected near Buried Land Mines." U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, ERDC/CRREL TR-00-5.
2) Phelan, J. M. and Stephen W. Webb, Matt Gozdor, Mark Cal, and James L. Barnett. (2001). "Effect of soil wetting and drying on DNT vapor flux: laboratory data and T2TNT model comparisons." Proceedings of the SPIE 15th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, Detection and Remediation Technologies for Mines and Minelike Targets VI, April 16-20, 2001, Orlando, FL.
3) Hutchinson, Kira, Scott Grossman, Thomas F. Jenkins, and Kelly Sherbondy. (2002). "Explosives-related chemical concentrations in surface soils over buried land mines." Proceedings of the SPIE 16th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, Detection and Remediation Technologies for Mines and Minelike Targets VI, April 1-5, 2002, Orlando, FL.
4) Rodacy, P. J., S. F. A. Bender, J. J. Bromenshenk, C. B. Henderson, G. Bender. (2002). "Training and deployment of honeybees to detect explosives and other agents of harm." Proceedings of the SPIE 16th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, Detection and Remediation Technologies for Mines and Minelike Targets VI, April 1-5, 2002, Orlando, FL.

KEYWORDS: Olfactory sensors, explosive-related chemical detection, real-time chemical sensing technologies,

A03-110 TITLE: Lightweight Laser Designator

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM SOLDIER WARRIOR

OBJECTIVE: Develop a compact, rugged, lightweight and efficient 1 mm solid-state laser for Army designator requirements.

DESCRIPTION: The Army has fielded several target designators over the past twenty years for both hand-held and airborne applications. Current technology, while an improvement over previous designs, is still relatively heavy. This SBIR topic seeks to push the current state-of-the-art in laser technology for operation over a large temperature range while maintaining minimum performance requirements and reducing the system mass by at least 50% of current lasers. Special consideration will be given to design concepts that can show operation over a large temperature range with little or no conditioning. System requirements are shown in Table 1.

Requirements
Wavelength................................................................1.064 microns
Output Energy...............................................100 mJ (typ), 80 mJ (min)

Pulselength ....................................................11-20 nsec FWHM
Beam Quality....................................................<8 mm-mrad
Mass...................................................<1.5 kg (goal) including all batteries
Operating Temperature......................................-32 C to +50 C
Maximum Allowable StandbyTime before Commencing Output....30 sec, with preference for instant "ON"
Repetition Rate..........................................10-20 PPS
Period of Operation...................................0-60 sec Continuous Operation with a Minimum of 4 Minutes between Periods of Operation
Minimum Number of Periods of Operation between Battery Changes......................................50
System Lifetime..................................................1x10^7 Shots

Table 1

PHASE I: Analysis and design of a prototype laser concept to meet the requirements in Table 1. Proposals must include optical, mechanical and electrical design concepts to address the needs for compactness, ruggedness and means of achieving the requirements. Any experimental work that can show evidence the design concept can meet the requirements will be considered for evaluation of Phase II award.

PHASE II: Contractor will build a prototype laser designator as designed under Phase I. The contractor will also perform measurements on the device to assess its performance against system requirements and specifications.

PHASE III: After successful completion of testing and evaluation of prototype, design and construction a production system for handheld and/or airborne platforms. PHASE III APPS: Phase III applications include use of a lightweight laser for marking and micro-machining/welding. A small lightweight laser can be easily mounted directly on robotic arms for use in cramped environments.

REFERENCES:
William T. Thodos, John Stanfill, "Lightweight Laser Designator Rangefinder (LLDR): Next-Generation Targeting for US Ground Forces," Proc. Military Sensing Symposium, Vol. 45, No 2, Dec 2000.

KEYWORDS: Laser, Designator, Optics, Weapons

A03-111 TITLE: Near Infrared Streak Tube

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a streak tube lidar receiver that is suitable for operation in the near infrared region of the optical spectrum.

DESCRIPTION: Imaging laser radar (LADAR or LIDAR) systems are needed for future military systems. The applications range from navigation and terrestrial mapping to missile targeting systems. Such applications could benefit greatly from the three-dimensional imaging capability of LADAR systems; however, the present technology needs further maturation.

Streak tubes provide high gain with a relatively low noise factor and the ability to convert high bandwidth information to spatial information that can be imaged and read out at a much lower bandwidth. These characteristics make them well suited for imaging lidar receivers[1]. Two systems, based on streak tube lidars, are being produced for oceanic mine counter measures for the Navy[2,3]. In those applications the streak tube response is optimized to provide good response at wavelengths compatible with transmission through seawater.

For many applications it would be preferable to have the wavelength of operation compatible with the so-called "eye-safe" region of the spectrum, i.e. near 1.54 micrometers. However, development of a streak tubes with near IR (NIR) photocathode has not been realized although suitable photocathode materials exist. In fact, there are no US vendors of streak tubes though there are companies with the capabilities required to do so. The DoD has made a significant investment in streak tube imaging lidars. The development of NIR sensitive streak tube and NIR streak tube lidar receivers will provide access to imaging lidar sensors appropriate for numerous applications.

PHASE I: Design a streak tube system capable of operation in the NIR.

PHASE II: Develop and build the streak tube designed in Phase I. Incorporate the streak tube in a lidar system and demonstrate operation at an "eye-safe: NIR wavelength.

PHASE III: A streak tube imaging lidar operating in the NIR has numerous applications in security, terrain mapping, and high-resolution imaging. Military applications include battlefield damage assessment, targeting, and identification.

REFERENCES:
1) McLean, J. W., "Streak-tube lidar allows 3-D ocean surveillance," Laser Focus World, January 1998: 171-176.
2) http://www.dau.mil/pubs/pm/pmpdf00/jacom-j.pdf
3) http://www.chinfo.navy.mil/navpalib/policy/vision/vis02/vpp02-ch3r.html
4) U.S. Patent 5,047,821, Costello, Spicer and Aebi, (1991).

KEYWORDS: Streak Tube

A03-112 TITLE: Security for Wireless Handheld Devices

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO-C3T PM Effects

OBJECTIVE: Perform research into strong Authentication Techniques for Handheld Wireless devices. It should be noted that some commercial wireless applications, such as Bluetooth, incorporate weak authentication. The authentication security solutions formulated would be extremely useful to both the commercial and military worlds. Note that it is anticipated that the authentication security solutions formulated would also be extremely beneficial in the Homeland Defense application by protecting critical computer network infrastructures.

DESCRIPTION: In both the commercial world and military world Authentication Techniques are being recognized as a major emerging problem. It is vital to protect computers and computer networks from hacker and foreign power threats. There are a number of commercially available strong Authentication products for larger computers, but there are a dearth of strong Authentication products for Handheld Wireless devices. In particular the Authentication techniques used in commercial wireless products (such as Bluetooth) are weak. This research will investigate new and innovative approaches for strong Authentication solutions for Handheld Wireless devices.

PHASE I: Perform a study of possible computer and computer network strong Authentication solutions for Handheld Wireless devices. A set of alternatives 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: Military use would include strong Authentication solutions for soldiers who are assigned Handheld Wireless devices. These devices are becoming more prevalent in the military. Commercial uses would include personnel who are assigned Handheld Wireless devices 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 strong Authentication solutions formulated would also be extremely beneficial in the Homeland Defense application by protecting critical computer network infrastructures against outsiders attempting to break into the network.

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1) "Computer Communications Security" by Warwick Ford. Prentice-Hall 1999.
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4) www.bluetooth.com
5) www.blueunplugged.com
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KEYWORDS: Strong Authentication, Authentication, Handheld Wireless Technologies

A03-113 TITLE: Terrain Aware Network Planning Tools

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM WIN-T

OBJECTIVE: Future Army tactical networks will require a network management tool that can assist the soldier with planning and designing the topology of on-the-move networks to support the Army Objective Force (OF) and Future Combat Systems (FCS) operations. This is a requirement from the battle command chunk lead that is responsible for C4ISR operational capabilities. This planning tool must indicate the performance, throughput, bandwidth, link quality and ad hoc capability of a tactical network topology by analyzing terrain data (both elevation and surface features), RF propagation of relevant Army tactical radio frequencies, weather effects, node mobility, and network topology (routing convergence and dynamic reconfiguration latencies) using embedded modeling and simulation capabilities. The Net planning aspect relating terrain to placement of communications assets is not being addressed by any comms program. This tool must have the capability to provide a visual indication of network topology and performance changes caused by mission related node mobility for dynamic re-planning purposes and the overall system must be fully integrated with the ability to be hosted in a small hardware footprint (e.g., notebook computer).

The objective is to utilize network and communications-provided information in order to adaptively and independently automate the planning of the information and signaling flows thereby improving maintaining the quality of voice, data and video applications using state-of-the-art microprocessor technology. The terrain aware network planning tools are needed to automatically and systematically control and maintain, and in real-time, the individual information and signaling flows caused by terrain, mobility, and environmentally induced variations characterized by sporadic connectivity and varying quality in the networking and communications links thereby aiding and maintaining the required quality of voice, data and video applications used in the Warfighter network supporting the OF and FCS.

DESCRIPTION: Future Army tactical communications networks must adapt to evolving combat doctrine that requires clients and hosts in the communications network to be on-the-move and operational over multiple terrain topologies, radio frequency spectrum environments, and atmospheric weather conditions. The communications networks supporting the Warfighter's OF and FCS will utilize a multitude of platforms – mobile terrestrial nodes, unmanned aerial vehicles, manned aerial vehicles, and satellite assets. The planning phase of the Warfighter network will be continuous throughout all phases of military operations. The management of the multiple platforms supporting the Warfighter network requires a complex innovative integration of technologies that must be provided to the soldier in a user friendly, concise, and effective planning tool. Given inputs from the military mission, situational awareness of communications assets, terrain topology, radio frequency environment, and atmospheric conditions, the terrain aware network planning tools must provide the soldier a means to configure the Warfighter network to support the mission. This planning tool must indicate the performance, throughput, bandwidth, link quality and ad hoc capability of a tactical network topology through analysis of the terrain data (both elevation and surface features), RF propagation of relevant Army tactical radio frequencies, weather effects, node mobility, and network topology (routing convergence and dynamic reconfiguration latencies) using embedded modeling and simulation capabilities. This tool must provide the soldier doing the planning with a visual display of network topology and performance changes caused by changing mission requirements related platform node mobility and dynamic real-time Warfighter network re-planning. This planning tool must be fully integrated with the ability to be hosted in a small hardware footprint (e.g. notebook computer).

PHASE I: Research, trade-off and design prototype hardware/software modules for microprocessor-based platform for automated Terrain Aware Network Planning Tools using embedded modeling and simulation to provide a capability to automatically and efficiently analyze terrain and environmental data in real-time to control the communication flows, and therefore, the quality of voice, data and video applications required to support delivery of battle command and control for the Warfighter network. Phase I addresses networking and communications systems design for hardware/software modules and includes the required design documentation. Phase I must includes a program management plan delineating the program tasks to achieve a Phase II prototype of the Terrain Aware Network Planning Tools.

PHASE II: Develop, test, integrate and demonstrate the microprocessor-based platform for automated Terrain Aware Network Planning Tools using embedded modeling and simulation to provide a capability to automatically and efficiently analyze terrain and environmental data in real-time to control the communication flows, and therefore, the quality of voice, data and video applications required to support delivery of battle command and control for the Warfighter network. Demonstration will first be performed at the contractor's plant and may include demonstration at a Government installation (e.g., CECOM). Phase II must includes a program management plan delineating the program tasks to achieve a Phase III commercial product or equivalent of the Terrain Aware Network Planning Tools.

PHASE III DUAL USE COMMERCIALIZATION (Real-world Examples): The Phase III microprocessor-based automated Terrain Aware Network Planning Tools will bring advanced technology to military networking and communications planning to deliver quality commander's critical information. The primary military application is developing advanced network aware technology for network-centric communications directly to the military commander's real-time products used in the delivery of Warfighter critical information. The primary commercial application will bring new network planning technologies offering the opportunity of network equipment manufacturers to develop new products for use in situations such as disaster relief and actions required by emergency task force efforts by local, state, and federal agencies.

REFERENCES:
1) Battle Command Handbook found on the WWW Site: http://cacfs.army.mil/index1.htm.)
2) Joint Tactical Architecture (JTA) available at http://www-jta.itsi.disa.mil/jta/JTA40_071702.pdf

KEYWORDS: Battle Command, IETF, Network Planning, Warfighters Information Network (WIN), Objective Force, Future Combat Systems, Wide Area Network (WAN), Terrain Analysis, Mobile Networking, Internet, Mobile IP, Modeling, Simulations, Network Management, Frequency Spectrum Management

A03-114 TITLE: Network Protocols for Onboard Satellite Packet Routing

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM WIN-T

OBJECTIVE: Develop packet switching protocols capable of providing efficient network access to satellite resources with the intention of passing IP traffic across onboard satellite router/switches. This will involve analysis of Layer 2 versus Layer 3 techniques for packet switching/routing. Developed protocols will perform packet switching according to pre-defined IP Quality of Service prioritization to maintain the overarching end-to-end QoS Scheme, as well as be able to incorporate some means of securing network traffic.

DESCRIPTION: The Future Combat Systems (FCS) / Objective Force (OF) communications architecture places reliance on satellite communications as a means of maintaining connectivity across remote units. The employment of IP routers on satellites is a future capability envisioned for Transformational Communications to reduce packet latency and minimize the ground infrastructure necessary to support satellite communications. Part of this function involves passing encrypted IP packet traffic with different priorities across satellite links between terrestrial networks. This effort is required to ensure that critical drivers to implement IP routers in the satellite and ground stations. This includes identifying the various options such as layer 2 vs. layer 3 solutions, protocols on satellites and in the terminals, and impacts of crypto on the implementation scheme. In addition, these solutions shall be analyzed and prototyped, to enable the Army to move forward with insight into the technology necessary to fulfill its planned future SATCOM architecture. Additionally, efficient network access protocols that link terrestrial networks via satellite routers/switches are required to bring this SATCOM architecture. This should include all tradeoff analysis to determine the best means of this satellite access. Layer 2 vs. Layer 3 solutions exist, however, a comparative study is required to identify a solution that is efficient and maximizes performance. Packet encryption needs to be included in this analysis.

PHASE I: Perform qualitative trade studies and analyze existing satellite access protocols. The primary focus should be on the advantages and disadvantages between Layer 2 and Layer 3 approaches to packet routing over satellites. Also to be addressed is the method of maintaining a MOSIAC-like QoS scheme end-to-end across satellite links, as well as providing the means to secure these links. Additionally, a forward-looking architecture document will be written which identifies the operational, technical, and functional characteristics of an efficient system comprised of a router-in-the-sky and ground terminals. It should detail these characteristics and the design approach that can be employed to yield the desired system. Included should be anticipated issues, both in transition and objective systems, as well as justifications for the future approach to be taken.

PHASE II: Develop and demonstrate a protocol model suite to support the identified objectives. The protocol approach taken should reflect conclusions drawn from the trade study from Phase I. Conduct simulation testing to prove concept feasibility and performance in an operational scenario. The results of developed models should provide input to a technical report describing the detailed defined system architecture and its expected performance parameters. Included should be a protocol design document used as the basis for the generated models that provides enough detail to yield a coded implementation.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian communications applications where there is a need to reduce the management of resources and increase the efficiency while maintaining robust wide-area connectivity with minimal or no terrestrial infrastructure. Requirements and demand in commercial markets are real and growing to include sporting events and highly populated areas. An example of HLS applicability would be overseas peacekeeping operations or emergency response/disaster relief operations.

REFERENCES:
1) http://www.utdallas.edu/~ravip/papers/ets99.satellite.pdf Routing in Leo-based satellite networks.
2) http://citeseer.nj.nec.com/cache/papers/cs/11051/http:zSzzSzwww.ee.surrey.ac.ukzSzPersonalzSzL.WoodzSzpublicationszSzWood-et-al-ip-routing-issues.pdf/wood01ip.pdf IP; Routing over satellite constellations.
3) http://www.ee.surrey.ac.uk/Personal/L.Wood/publications/Wood-et-al-effects-on-TCP.pdf; Effects on TCP of Routing Strategies in Satellite Constellations.
4) http://www.ee.surrey.ac.uk/Personal/L.Wood/publications/PhD-thesis/wood-phd-thesis.pdf; Internetworking with satellite constellations.
5) http://citeseer.nj.nec.com/cache/papers/cs/23225/http:zSzzSzusers.ece.gatech.eduzSz~eylemzSzbgps.pdf/network-layer-integration-of.pdf; Network Layer Integration of terrestrial and satellite IP Networks over BGP-S.

KEYWORDS: satellite communications, SATCOM, networking, IP routing

A03-115 TITLE: Small, Bandwidth Efficient Satellite Communications Modems and Waveforms

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM WARFIGHTER INFORMATION NETWORK-TACTICAL (WIN-T)

OBJECTIVE: Design and build a small, bandwidth efficient satellite communications modem suitable for use with small aperture antennas in moving vehicles where communications is not the primary mission of the vehicle.

DESCRIPTION: Satellite communications while on the move (SOTM) is a very important requirement for the Army's Future Combat Systems/Objective Force. This capability allows warfighters to disperse to any location on the battlefield without being constrained by the limited ranges of terrestrial communications. The size, weight, and power limitations of battlefield vehicles mandate that SOTM antennas be small (generally around 16 inches in diameter). Networks comprised of many SOTM terminals do not manage satellite resources (i.e. power and bandwidth) in an efficient manner. Satellites have a limited power budget that must support all of the communication links utilizing the available bandwidth. As the satellite terminal antenna aperture decreases, the power per bit necessary to close the downlink from the satellite increases considerably. As a result, it is not uncommon for small SOTM terminals to require orders of magnitude more power than larger SATCOM terminals utilizing the same amount of bandwith. The Future Combat Systems and Objective Force systems architectures require a large number of small, on the move, SATCOM terminals. These networks will consume a large portion of the satellite's power budget to utilize a small percentage of the available bandwith. This is an inefficient use of very important, and very expensive, satellite communications resources. Satellite power budgets will not be able to execute these architectures unless significant increases in power efficiency and bandwidth allocation are realized. New modem and waveform technologies are needed to increase data rates and bandwidth utilization without increasing the power requirements. Cross polarization and channel sharing schemes like demand assigned multiple access (DAMA) are examples of traditional methods that need further study and refinement, while new methods may need to be developed. In addition, power efficient waveforms with low signal to noise ratio carrier acquisition are needed for on-the-move operations with small antennas.

PHASE I: Develop overall system design that includes specification of the modem, waveform(s) and satellite access protocols and how these will lead to efficient utilization of satellite resources by networks of small terminals.

PHASE II: Develop and demonstrate a prototype modem in a realistic environment. Conduct testing to prove feasibility over extended operating conditions and ability to support networks of numerous small terminals.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian communications applications where there is a need for on-the-move satellite communications – for example, in overseas peacekeeping operations, emergency response/disaster relief operations, mobile news coverage, and in-vehicle business communications and entertainment systems.

REFERENCES:
1) Army Vision of Future SATCOM Support, http://www.army.mil/ciog6/references/armysat/Chapter_12.PDF
2) Space Communications Protocol Standards (SCPS) Homepage, http://bongo.jpl.nasa.gov/scps/
3) Employment Of ACTS Mobile Measurements At 20 GHz For Prediction Of Earth-Satellite Fades Due To Trees And Terrain, http://acts.grc.nasa.gov/docs/SCAN_20010910164047.PDF
4) Encryption And Error Correction Using Random Time Smearing Applications To Mobile And Personal Satcom, http://acts.grc.nasa.gov/docs/SCAN_20010913161741.PDF
5) Finite State Markov Models For Error Bursts On The ACTS Land Mobile Satellite Channel, http://acts.grc.nasa.gov/docs/SCAN_20010911124730.PDF
6) K/Ka-Band Channel Characterization For Mobile Satellite Systems, http://acts.grc.nasa.gov/docs/SCAN_20010911145550.PDF

KEYWORDS: Satellite communications, modems, waveforms

A03-116 TITLE: Satellite Access Using Unmanned Aerial Vehicles

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM WARFIGHTER INFORMATION NETWORK-TACTICAL

OBJECTIVE: Design and build an airborne satellite communications payload capable of operating in an unmanned aerial vehicle and interfacing with a separate terrestrial communications relay payload while sending communications and network traffic over the appropriate link based on policy inputs.

DESCRIPTION: The Future Combat Systems (FCS)/Objective Force (OF) communications architecture places a high reliance on unmanned aerial vehicles (UAVs) as "relays in the sky". Part of this function includes UAVs serving as entry points to provide satellite communications capability to terrestrial radio networks without requiring satellite terminals on the ground. It is challenging to design a small satellite communications (SATCOM) terminal and antenna that can fit in the size, weight and power requirements for planned Army UAVs and maintain a continuous SATCOM link while in flight. This includes tradeoff between UAV payload and range capability and the terminal and antenna size and supported satellite communications data rate, to satisfy the requirements of the FCS/OF communications architecture. Another challenge is to provide a robust and dynamic networking capability that will enable effective use of this satellite communications capability by sending traffic over the most appropriate link (from the UAV to the ground, another UAV, or satellite) based on connectivity to the destination, traffic priority and amount of traffic. Various aspects of this technology have been demonstrated in current commercial and military efforts in migrating to Ka-band satellite communications using small, portable and on-the-move terminals and in mobile, ad hoc networking. Also, UAVs payloads are already under development to provide communications relays between terrestrial users. The challenge is to apply and integrate these technologies and concepts to extend the developing two-dimensional network (terrestrial and UAV) to a third (space) dimension while making the most effective use of the limited UAV payload space and UAV relay and satellite communications bandwidth. Without this capability, terrestrial users will require multiple radio and antenna assets for full-spectrum connectivity, or they will not have access to effective, continuous communications under all circumstances. The number of SATCOM terminals required for connectivity will be much greater, as will the cost to purchase the number of terminals required to support the FCS/OF communications architecture.

PHASE I: Develop overall system design that includes specification of UAV satellite communications payload, interface(s) to UAV communications relay payload, and smart networking algorithms/protocols. Deliverables for Phase I should include a System Design Report and a Protocol Design Document.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian communications applications where there is a need to reduce the number of terminals per user while maintaining robust wide-area connectivity with minimal to no terrestrial infrastructure – for example, in overseas peacekeeping operations or emergency response/disaster relief operations. Commercial sectors are proposing many systems for air craft comms support in areas of large population to include manned/unmanned/blimbs to augment comms requirements.

REFERENCES:
1) Army Vision of Future SATCOM Support, http://www.army.mil/ciog6/references/armysat/Chapter_12.PDF
2) Close Range - Tactical Unmanned Aerial Vehicle (CR-TUAV), http://www.fas.org/irp/program/collect/cr-tuav.htm
3) UAVs and HAPs - Potential Convergence for Military Communications, http://www.elec.york.ac.uk/comms/papers/tozer00_ieecol.pdf
4) Application of IRIDIUM® System Technology to UAV Based PCS, http://www.argreenhouse.com/society/TacCom/papers98/24_02i.pdf

KEYWORDS: satellite communications, SATCOM, UAV, networking

A03-117 TITLE: Disposable Micro-Radios for Sensor and Munitions Networks

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM RUS APM

OBJECTIVE: To research, design, and prototype a disposable micro-radio for sensor and munitions networks. The radio must incorporate RF waveform security (LPI, LPD, & AJ) required of military radios and be able to survive in a military environment through the use of adaptive ad-hoc networking protocols.

Although the Networked Sensors for the Objective Force (NSOF) is currently developing radios, known as the "Blue" and "Orange" radios, for the ATD, the need for a smaller and less expensive radio exists. This radio will satisfy the need for communications for the unmanned sensor and munition systems that will be deployed in a disposable manner. A disposable radio, with RF waveform security, will also have a strong aplicability in both Homeland Security and commercial applications.

DESCRIPTION: The US Army's Future Combat Systems (FCS) and Objective Force Warrior (OFW) will rely on the use of unattended, tactical sensors to detect and identify enemy targets in order to survive on the future battlefield with less armor protection. Successful implementation of these critical sensor fields requires the development of low cost sensors, processors and the specialized communications infrastructure needed to disseminate the sensor data to provide relevant situational awareness information. The sensor communications must support both static deployed and mobile ground and air robotic sensor arrays with robust, secure, stealthy, and jam resistant links. It is envisioned that sensor networks can be deployed in a two tiered communications architecture that includes a lower sensor sub-layer consisting of acoustic, magnetic, Chem/Bio and/or seismic detectors and an upper sub-layer consisting of infrared or visual imaging cameras. The upper sub-layer can be cued by the lower sub-layer and provides a seamless gateway link to higher echelon tactical networks such as the Tactical Internet.

The NSOF Advanced Technology Demonstration (ATD) communications effort will also focus on providing Objective Force systems such as FCS, Objective Force Warrior with the critical situational awareness data needed for survivability. The communications systems supporting this functionality must be designed such that unattended ground sensor data can flow seamlessly from the lowest unattended tactical sensor echelons into the Army's Next Generation Tactical Internet while also allowing the "fusing" of the data with other intelligence information for correlation within a tactical command and control node. NSOF will realize this capability using advanced communications technologies that were previously unavailable. These technologies include robust, self-organizing networking protocols, energy management techniques, and stealthy, secure, jam resistant radio equipment for a significantly enhanced communications capability.

Applications such as Objective Force Warrior will also require the sensor networks to be miniaturized, disposable and low cost. Soldier portable sensor networks will be carried by dismounted soldiers as buildings are cleared in urban areas. The sensors will continuously monitor the urban areas as the soldiers continue their missions providing alerts as needed. Miniaturization of key components and power considerations will need to be examined. New manufacturing techniques have been emerging to allow radio frequency components and sub-systems in ultra-miniaturized packaging that can be cost effective in sufficient quantities. These advanced packaging technologies will be critical in achieving the requirements.

This innovation using sensor network technologies will benefit the Army transformation. Project Manager, Robotics and Unmanned Sensors (PM RUS) under the PEO IEWS organization supports the concept of networked communications for its sensor systems. PM RUS would be the organization to put the sensor networks in the field. The Joint Program Office Joint Tactical Radio System (JPO JTRS) would oversee the communications acquisition to ensure JTRS compliance of the developed waveform for joint use on any JTRS compliant platform.

Every effort will be made to ensure the commercial off the shelf market is leveraged for the networked communications. 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. HLS applications will increasingly rely on miniaturized disposable sensor networks for perimeter and infrastructure defense as the threat continues.

PHASE I: Research and develop a design for a disposable micro-radio for military and homeland security sensor and munition networks. The radio design and architecture shall be minimal in power, cost, size, and weight. The radio design shall include the operating and routing software design needed to form an low-power and power-aware ad-hoc sensor/munition network. The radio's waveform design shall include securities in the form of low probability of interception, low probability of detection, anti-jam, and data encryption. The radios operating frequencies shall be consistent with the more efficient frequency ranges found with the current near ground propagation models. The radio design shall include a link-budget analysis showing that the radios are capable of providing RF communications over distances of at least 100 meters in both urban and rural terrains. Use of existing components or radios designs in novel ways is encouraged. If a existing design is to be used, a descriptive plan must be included documenting how the design will be modified to include the waveform securities and ad-hoc radio software, if needed, while minimized the power, cost, size, and weight of the radio.

PHASE II: Prototype and integrate the radio design and ad-hoc radio software that was approved in Phase I. If a modified radio hardware design is used, the related radio software and networking software shall be updated to reflect the changes in radio design. A demonstration of a sensor network consisting of 50 to 100 prototype radios developed in Phase II shall be given in a realistic homeland security application.

PHASE III: The radio hardware and software that was developed and prototyped in Phase I and II shall be transitioned to both military and commercial sectors. In the military sector, the radio hardware and software could help fill the void in the Networked Sensors for the Objective Force ATD for an inexpensive and disposable radio for sensor and munitions networks. This radio would be used to form sensor networks in areas where lower-precision, as compared to the ATD, sensors are used. They may also be used to awaken the more powerful NSOF ATD sensor nodes allowing the ATD sensors to remain in a more power-efficient sleep state. In the commercial sector, the developed radio will increase the capabilities of Homeland Security sensor networks. A possible use of this radio in a homeland security application is a quickly and inexpensively deployed perimeter control system used by local or State authorities. The developed radio will also be applicable in industrial applications where there is a need for a inexpensive but secure radio network. A possible application in the industrial world would be for monitoring the soil conditions (acidity, moisture, etc.) found at the larger farms.

REFERENCES:
A possible radio with no waveform security, data encryption, or networking software:

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2) http://www.xbow.com/Products/Product_pdf_files/Wireless_pdf/6020-0042-01_A_MICA2.pdf
3) Another low-power disposable sensor radio with no waveform security or data encryption:
http://www.sentechbiomed.com/products.htm see product #s0079
4) A single chip radio solution with no waveform security, data encryption, or routing protocols:
http://www.xemics.com/internet/products/products.jsp?productID=33
5) White paper on low power sensor networks: www.mit.edu/~rmin/research/min-vlsi01.pdf
6) Paper on low power encryption methods for wireless networks:
http://portal.acm.org/citation.cfm?id=274833.274845&coll=portal&dl=ACM&idx=J804&part=affil&WantType=affil&title=Wireless%20Networks&CFID=9155745&CFTOKEN=21451694#

KEYWORDS: disposable low cost unattended ground sensor, LPI LPD AJ waveform protocol, adaptive, ad hoc

A03-118 TITLE: Digital Dynamic Pre-Distorter for High Power Amplifiers for Wideband Digital Radios

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM TRCS

OBJECTIVE: Develop a digital pre-distorter for RF waveforms in the 2-2000 MHz range to linearize the frequency response of multi-carrier high power amplifiers over bandwidths of 100 MHz or more. High dc-to-rf efficiency and low intermodulation distortion are required. This technology would be applicable to all RF transmitters, especially to the JTRS communication system as well as any communication system for Homeland Security.

DESCRIPTION: In an RF transmit system, a low power exciter signal is amplified by a chain of amplifiers culminating in a high power amplifier (HPA). In modern wideband multi-carrier communication applications, such as the JTRS radio, the cumulative transfer function of entire amplifier chain must be linear over this wide frequency band. The conventional approach of combining the RF outputs of individual single-carrier narrowband HPAs to reduce intermodulation distortion wastes too much power and is too expensive. Typical wideband amplifiers inevitably exhibit a trade-off between high power-efficiency and nonlinear distortion. The more efficient wideband amplifiers can only be used if the input signal to these devices is predistorted to compensate for the amplifier nonlinearity. HPA linearization techniques using digital pre-distorters at baseband are available but are limited in bandwidth and are not fast enough to correct for dynamic signal-induced nonlinearities. Dynamic (real-time) digital pre-distortion at RF frequencies provides a way to increase bandwidth, DC-to-RF efficiency, and reduce cost, and size of high-power transmit amplifiers, more effectively than at baseband. Solutions are needed for real-time adaptive digital pre-distorter circuits for bandwidths of 100 MHz or greater in the 2-2000 MHz frequency range. Compatibility with ultra-fast digital-to-analog converter technology for direct digital synthesis of RF waveforms is required.

PHASE I: Demonstrate the proof-of-principle of the digital predistorter circuit architecture through simulation and experimentally verify the operation of circuit components.

PHASE II: Build and demonstrate a complete digital pre-distorter circuit.

PHASE III: Military Application: The wideband real-time digital predistorter technology could be inserted into future JTRS radio family members as a pre-planned product improvement. This technology could also be directly applicable to any communication system for Homeland Security.
Commercial Application: The wideband real-time digital predistorters will find widespread use in commercial wireless communications, especially the third generation (3G) and beyond, where cost savings for multi-carrier base stations would be significant.

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1) Frederick H. Raab et al, "Power Amplifiers and Transmitters for RF and Microwave," IEEE Trans. MTT, vol. 50, pp. 814-826, March 2002.
2) Allen Katz, "Linearization: Reducing Distortion in Power Amplifiers," IEEE Microwave Magazine, December 2001.
3) P. M. Asbeck, L. E. Larson, I. G. Galton, "Synergistic Design of DSP and Power Amplifiers for Wireless Communications," IEEE Trans. MTT, vol. 49, pp. 2163, November 2001.
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KEYWORDS: Digital Pre-distorter, RF Waveforms, Multi-carrier High Power Amplifiers

A03-119 TITLE: PAMELA: Propagation Analysis and Modeling Experiments for Laser Applications

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM AJCN

OBJECTIVE: Laser communication has undergone significant investigation on its critical impact to the

Transformation Communication Study (TCS) at the Pentagon. Several programs throughout DoD have been ongoing to address issues of technology. However, there has been limited resources to address the modelling of the laser link with respect to atmospheric turbulence. Very little has been done to integrate laser propagation parameters with turbulence metrics to predict limits on tactical performance and applications. Its is of dire need to undertake this type of analysis to predict tactical feasibility of laser communication for ground/airborne/space applications.

Free-space laser communication and active laser imaging are emerging technologies that share a number of common challenges. Both of these technologies involve the focusing and transmission of laser energy through the atmosphere and share problems related to signal reception, tracking, pointing, laser speckle, and information processing. With the advent of emphasis on space based military network, it is critical to have a complete model to determine practical constraints of military use.

Modeling of this nature is extremely important for the deployment of fielded military systems.

The objectives of this research are to:
· Propose a novel integration of atmospheric effects with mitigation and data communication coding techniques
· Validate experimentally the transmission of information using novel types of sources
· Investigate aspects of polarization and partial coherence
· Incorporate model in a network

DESCRIPTION: Laser communication could have a key role in three significant areas in high bandwidth communication systems: terrestrial to terrestrial, satellite to terrestrial, space craft to satellite, or a variation of all three. On the terrestrial side, wireline network have been preferred, but recent advances have made free space optical communication advantageous for a variety of applications including those involved in which ground installation may be prohibitively costly. For military applications, covert laser communication is harder to intercept than RF systems because of its smaller angle of acceptance. In satellite systems, such as Teledesic, cross-link pipelines are needed to transmit gigabits of information to interconnect globally. Network manager may be required to downlink data directly from LEO satellites or send data from an on-the-move vehicle.

PHASE I: Develop a theoretical model basis. Model should be convincing and made generic to a wide range of applications and implementations of laser communication. Framework of the model should include key system performance criteria of a data communication system and include atmospheric propagation parameters that have effect on these metrics.

PHASE II: Develop software and GUI (Graphics User Interface). Debug and finalize software code. Validate model with real experimental data. Package software and deliver to CECOM.

PHASE III COMMERCIAL APPLICATIONS: Laser communication has a variety of applications due to its high bandwidth, “no cable” and quick installation. A high probability of commercialization is expected. Potential commercial applications include high bandwidth video transmission, 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.

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KEYWORDS: high speed networks, high capacity communication, wavelength division multiplexing, optical networks, laser communication

A03-120 TITLE: Smart Single or Multiple Beam Forming Antennas in the 1 to 2 GHz Range

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM TRCS JTRS and PM-Aviation Mission Equipment

OBJECTIVE: To advance the state-of-the-art in the conformal antenna technology. To produce an airworthy prototype of a flat panel beam steerable and possibly tunable antenna potentially covering the 1 to 2.5 GHz frequency band for low-speed aircraft.

DESCRIPTION: The Joint Tactical Radio System (JTRS) is a multi-band, multi-mode radio, and will provide a wideband networking waveform (WNW). The WNW is currently being designed to provide high rate situational awareness data at rates up to 8 Mbps. Additionally, secure wireless local area networks (SWLAN) and flying local area networks (FLAN) provide high data rate signals. Current airborne and ground vehicular antennas will not provide adequate gain to close these links. Low profile, high gain, condensed-beam, tuneable, and steerable antennas are some of the viable improvements to the current antenna systems.

PHASE I: Provide a feasible design of a flat-panel, steerable, and possibly tuneable antenna in the 1 to 2.5 GHz frequency range; based on related work in this area. PHASE I Option: Provide a complete design package of the 1 to 2.5 GHz antenna from Phase I.

PHASE II: Develop and demonstrate an airworthy prototype of an approved design in the lab environment. Conduct testing, with government personnel, of the prototype on a military airborne and/or ground platform.

PHASE III: Commercialization of product. Possible applications include cellular base station and mobile antennas for high-rate data transmission, wireless LAN data links, and mobile Inmarsat satellite links.

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KEYWORDS: Smart Antenna, Tunable, Beam-Forming, Tracking, Flat-Panel, High-gain, Array, MMIC

A03-121 TITLE: Networked System on a Chip for C4ISR

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO C3T/PM CCS

OBJECTIVE: The overall objective of this effort is to design, develop, test, and evaluate the technology needed to provide a network oriented C4ISR chip. In a high level systemic context, a C4ISR system could be viewed as a collection of (radio based) communicating and processing elements. It is the ultimate goal that each one of these communication and processing elements could be implemented by a single re-configurable VLSI (Very Large Scale Integrated circuit) or small set of such VLSI chips.

DESCRIPTION: With the stated objective to design, develop, test and evaluate the technology to produce (ultimately) a single chip that provides a set of C4ISR functions, a number of related technology areas need to be defined and developed. This effort should address the use of low power radio based network protocols, (potentially collaborative) energy aware application level digital signal processing, as well as VLSI implementation and energy consumption concerns in a unifying and consistent manner. Innovative and novel state of the art techniques in the above areas are encouraged. It should be noted that the term C4ISR includes all forms of sensor processing, as well as the more traditional C2 reporting and messaging functions. The effort could also consider the emerging automated tools for specification, design, implementation, testing and verification that could be used in the chip design and development process. Innovative design, specification and analysis techniques to be used in the development of a C4ISR chip (or chip set) are also encouraged.

PHASE I: Overall Technology Assessment and High Level System on a Chip Design. In this first phase, an overall technology assessment in the areas of radio based, low power networking protocols, chip implementable radio technology, and VLSI implementation will be made for the FY2006 time frame, consistent with the Army FCS program and FCS LSI (Future Combat System Lead System Integrator) team. The results of this technology assessment will be documented as part of the Phase I deliverable report. Based on the technology assessment, a specific sensing and networking problem will be defined suitable for both an FCS (Future Combat System) and Homeland Security type of application. A high level system design will be undertaken to design and specify the chip, or chip set, so the feasibility of implementing such a chip solution is defined and determined.

PHASE II: Detailed Design and Prototype Implementation. In this phase of the program, a detailed system level and resulting chip implementation design will be undertaken. At the completion of the detailed design phase, a prototype implementation of a small number ( ~10 ) units will be undertaken. Maximum use of commercially available VLSI components may be made in this first prototype, but with the ultimate goal of going to a single chip. The Phase II deliverable includes the demonstration of the operation and functionality of the chip (or chip set) in a laboratory environment as well as an assessment of the performance (including energy/power consumption) achieved.

PHASE III: It is anticipated that the production version of the networked system on a chip could be configured for Homeland Defense or commercial application. Typical combat oriented military application might include acoustic, seismic, and passive IR monitoring of an anticipated enemy avenue of approach, while the HomeLand Defense application might include monitoring of bridges, tunnels or other public areas.

REFERENCES:
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2) The UCB Wireless Research Center (http://bwrc.eecs.berkeley.edu/
3) The MIT uAMPS Program (micro Adaptive Multi-domain Power Aware Sensors ( http://www-mtl.mit.edu/research/icsystems/uamps)

KEYWORDS: Distributed Sensor Networks, VLSI, RF technology, energy aware networking protocols, energy aware collaborative signal processing

A03-122 TITLE: Orthogonal Coding for Code Division Multiple Access (CDMA)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO C3T

OBJECTIVE: The primary objective of this research is to study the high potential payoff of investigating unique orthogonal coding and its application to the Code Division Multiple Access (CDMA) technology using Spread Spectrum Multiplex Noise codes for secure and reliable wireless communications.

This WILL provide significant improvement in network capacity and data throughput. Application of this technique will also have an impact on the data integrity and security of the networks data. This could have direct applicability to various networks to include networks that use CDMA such as cellular networks, commercial SATCOM voice and data networks and Movement Tracking Systems.

DESCRIPTION: Improved orthogonal coding by using the Spread Spectrum Multiplexed Noise (MN) codes which could have direct commercial application as it can improve system capacity and data throughput. A virtually inexhaustible quantity of orthogonal Pseudonise (PN) code sets are generated from each MN code. This enables implementing orthogonal CDMA and a noise code switching network. Orthogonal CDMA eliminates the near/far ratio problem and maximizes the system capacity. It can also help in tactical employment for those reasons listed as well as improving potential system vulnerabilities. MN codes can be used for encryption and can be implemented and changed. One can also combine the coded signal with noise before transmission. The resulting transmitted signal could then not be detected. Application to CDMA provides a huge return to both commercial and military communications but is not limited to this in that the techniques can be applied to improve various networks. CDMA has direct application to the Army's wireless initiatives to include the Terrestrial Personal Communications Systems (TPCS) Program. TPCS has major benefits for secure wireless communications to the Objective Force as it has direct application to the Army's WIN-T program. PCS is a revolutionary approach to delivering secure voice and data in a handset, which is included in the MOSAIC ATD strategy. CDMA is the de-facto standard for commercial third generation wireless communications.

PHASE I: Study and recommendations report outlining existing approaches and their limitation with respect to the mobile tactical environment, hardware, and software descriptions, and plan for integration, enhancements and implementations required for the specific Army tactical system. Analyze applicability to utilizing in the PM WIN-T program.

PHASE II: The selected system of Phase I will be further developed by completing a specific design plan, fabrication and carrying out prototype demonstration.

PHASE III DUAL USE APPLICATIONS: The end product system capability will be further refined and optimized for both commercial and military use. Possible applications include law enforcement, emergency management, and commercial wireless communications.

REFERENCE:
IS-95 standard, CDMA 2000, UMTS
1) http://www.cdg.org
2) http://www.itu.org

KEYWORDS: Orthogonal coding, IS-95 CDMA, CDMA 2000, UTMS, spread spectrum, mobility, high data capacity, security, wireless communications

A03-123 TITLE: <u>Disposable Imaging Sensors</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Soldier Sensors

OBJECTIVE: The objective of this SBIR is to develop miniature, low-cost, low-power, manually deployable imaging sensor nodes with integrated communications links for use by the individual soldier in short to medium range distributed sensor network applications. The challenge of this project is to demonstrate a practical, robust, integrated sensors node concept that is projected to be very low cost in production. Specifically, this project requires the development of individual imaging sensor nodes that, as a minimum, include a silicon-based color visible/near infrared (NIR) CMOS imaging sensor with integrated video control and optimization circuitry, triggering sensor(s), NIR LED illuminator and augmentation control circuitry for optimal night imaging, and wireless communications receiver and transmitter link for demonstration in a Military Operations in Urbanized Terrain (MOUT) or complex environment.

DESCRIPTION: Disposable unattended ground sensor networks are highly desirable for close-to-the-fight situational awareness. To meet resolution requirements over a wide field of view, the pixel format of the CMOS visible/near-IR imaging array shall be nominally 640 x 480. The project shall consider an integrated CMOS imager electronics architecture that is capable of optimizing image quality and tailoring video format and frame rate within bandwidth and power constraints by implementing video processing functions on-chip or on the sensor node. Example functions include, but are not limited to: full frame or subframe integration, multi-frame ROI windowing, spatio-temporal filtering, video compression, flash memory storage, NIR illuminator auto-augmentation and control, and triggering sensor signal conditioning. Remote adjustment and selection of operational modes is highly desirable. The triggering sensors may include IR, seismic, acoustic or other nonimaging devices that serve to cue sensor operation and video transmission. A portable, handheld central controller unit with communications link that enables the individual solder to communicate, control and download information from multiple sensor nodes within a range of a few hundred feet shall be included.

PHASE I: Design and demonstrate by analysis a disposable imaging sensor network consisting of a minimum of 12 imaging sensor nodes with projected volume production cost estimates. Determine physical and performance specifications for each integrated sensor node component and interchangeability of triggering sensor technologies. The cost estimates shall include projected cost of the entire imaging sensor network.

PHASE II: Build, demonstrate and deliver a minimum of 12 imaging sensor nodes and central controller unit with functions and capability defined in the Phase I analysis.

PHASE III: Commercialize application for low-cost perimeter surveillance. There are many potential commercial applications for low-cost imaging sensors operating in the visible and near infrared with integrated communication technology including low-cost perimeter surveillance, security, law enforcement, machine vision and automated process control.

REFERENCES:
1) "Distributed Sensors for Land Warfare", Dr. AF Milton, US Army NVESD (5090-01), Proceedings of 2003 SPIE Conference, Orlando, FL.

KEYWORDS: CMOS, imaging sensor, IR, acoustic, seismic, illuminator, communications network

A03-124 TITLE: Automated Wafer Polishing for Epi-ready CdZnTe Substrates

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Demonstrate a process for batch-polishing large cadmium zinc telluride wafers.

DESCRIPTION: All military infrared imaging systems capable of multi-spectral detection contain a focal plane array 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 by depositing thin epitaxial layers onto cadmium zinc telluride (CdZnTe) substrate wafers by a process known as molecular beam epitaxy (MBE). Although MBE has been demonstrated to produce the most complex and the most sensitive detectors, it places severe restrictions on the quality of the substrate surface.[1] Currently, a technology for producing such surfaces on a new wafer is available only at a single foreign vendor. Moreover, a technology for re-polishing wafers to remove a HgCdTe layer that did not meet spec has not been demonstrated. These are significant factors in the high cost, and the resulting limited deployment, of current HgCdTe military systems.[2]

PHASE I: Show feasibility of a process for polishing CdZnTe wafers for use as substrates for molecular beam epitaxy of mercury cadmium telluride.

PHASE II: Demonstrate a prototype machine and a process for polishing and repolishing CdZnTe wafers. The machine must be capable of polishing multiple wafers, each with dimensions as large as 6cm x 6cm.

PHASE III DUAL USE APPLICATIONS: A successful demonstration of this machine for military epitaxy applications would lead to its adoption by the industry that manufactures similar wafers for x-ray applications.

REFERENCES:
1) IR Detector Technology; MDA Contract F61771-01-WE004 with Charles University, The Czech Republic.
2) Chemical-Mechanical Polishing 2000: Fundamentals and Materials Issues; R. K. Singh, R. Bajaj, M. Moinpour, M. Meuris,editors. Mat. Res. Soc. Symp. Proc. 613.

KEYWORDS: semiconductor wafer polishing; cadmium zinc telluride; molecular beam epitaxy; mercury cadmium telluride

A03-125 TITLE: Carbon Nanotube Obscurants for Survivability

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop carbon nanotubes to serve as improved infrared screening smoke particles.

DESCRIPTION: The infrared screening effectiveness of current smoke materials needs to be improved by about an order of magnitude based on the extinction cross section per volume of material. One approach is to employ fibers with high electrical conductivity, diameters on the order of several nanometers and lengths on the order of several micrometers. Carbon nanotubes fall into this category. In addition they are extremely strong and uniform in diameter potentially permitting dissemination as a single particle aerosol with little agglomeration and little fiber breakage.

Carbon nanotubes are currently very expensive to produce. Significant cost reductions can be realized by using multiwalled rather than single walled carbon nanotubes or by using carbon nanotubes of reduced purity. Carbon 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:
1) Dr. Janon Embury, "Maximizing Infrared Extinction Coefficients for Metal Discs, Rods, and Spheres", ECBC-Tech Report 226, Feb 2002, approved for public release, distrib unlimited.
2) Field Manual 3-50 Smoke Operations at www.adtdl.army.mil, General Dennis J. Reimer Training and Doctrine Digital Library.
3) Kristan P. Gurton and Charles W. Bruce, "Parametric Study of the Absorption Cross Section For a Moderately Conducting Thin Cylinder", Applied Optics/ Vol.34, No. 15/ 20 May 1995.
4) Proceedings of the Smoke/Obscurants Symposium, various, ECBC, ATTN: AMSSB-RRT-TD, Aberdeen

Proving Ground, MD 21010-5424.

KEYWORDS: smoke, obscurant, screening material, infrared, aerosols, nanoparticles

A03-126 TITLE: Multi-Dimensional Separations Technology for Proteomics

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO CB DEFENSE

OBJECTIVE: Analysis of the proteome is the next great challenge in biology following sequencing of the genome. Current techniques rely on 2-dimensional gel electrophoresis followed by mass spectrometry, and have difficulty distinguishing among proteins which differ only in post translational modifications. The objective is to develop a multi-dimensional separation technique with broad applicability in proteomic analysis.

DESCRIPTION: Proteins are the functional end products of gene expression and the sequencing of human, bacterial and other genomes will result in next generation biological materials for the Objective Force. Applications, described in detail by recent National Academy and Office of Net Assessment studies, include armor, power, soldier health and performance and sensors. There are two key issues: identification of a useful protein, and its subsequent production and purification.

When working with proteins from samples where genomic information is available (e.g., E. coli), proteins are separated by charge (pI) and molecular weight (MW), i.e., in two dimensions. The protein spot is then subjected to MALDI-TOF mass spectrometry and peaks matched against expected peptides. In the absence of genomic information one automatically assigns different spots to different proteins and performs laborious and expensive mass spectrometric analysis.

Extraction and purification of proteins currently relies on traditional protein biochemistry techniques which are sufficient for many high yield and non-modified proteins. However, when the protein is post-translationally modified (e.g., glycosylation, phosphorylation, amidation) or expressed in low abundance, these techniques are insufficient. Since these modifications are often responsible for the protein's biological activity, this issue is key.

The problem is to separate proteins on more than two-dimensional criteria of MW and pI in order to identify those whose amino acid sequences may be identical but which differ in post-translational modifications, hence functionality. Multi-dimensionality might be added by including functional criteria using approaches other than gels, such as MEMs or array devices.

PHASE I: Propose a set of dimensions in addition to traditional charge and molecular weight to functionally separate proteins. Select a family of proteins whose subspecies differ only in level of expression and degree of post-translational modification.

PHASE II: The objective of Phase II is to design a platform or device capable of separating proteins in more than two dimensions. An example of an additional dimension might be protease activity, but others are required. Such a device could be based on ¾ but is not limited to ¾ microelectromechanical systems. The approach should include a complete protocol including extraction, purification and storage conditions and must be demonstrably applicable to different tissue types and protein species.

PHASE III: A multi-dimensional system for protein separation would have virtually unlimited applications in all aspects of proteomics, from drug discovery to biological assays.

REFERENCES:
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throughput detection and specificity assignments of carbohydrate-protein interactions. Nature Biotechnol. 20(10):1011-1017.
3) Hirabayashi J, Kasai K. (2002) Separation technologies for glycomics. J. Chromatography B Analyt Technol Biomed Life Sci.771(1-2):67-87.
4) Prutsch A, Lohaus C, Green B, Meyer H E, Lubben M. Multiple posttranslational modifications at distinct sites contribute to heterogeneity of the lipoprotein cytochrome bo(3). (2000) Biochemistry 39(21):6554-63.
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6) Soderquist A M, Todderud G, Carpenter G. (1988) The role of carbohydrate as a post-translational modification of the receptor for epidermal growth factor. Adv Exp Med Biol. 231:569-82.
7) Opportunities in Biotechnology for Future Army Applications, Board on Army Science and Technology, National Research Council, National Academy of Sciences (2001).
8) Exploring Biotechnology, Opportunities for the Department of Defense, Office of Secretary of Defense – Net Assessment (2001).

KEYWORDS: Protein purification, post-translational modification, protein extraction, MEMs, proteomics

A03-127 TITLE: Buried Mine/Unexploded (UXO) Detection and Identification Improvement Through Characterization and Innovative Incorporation of Sensor Background Noise/Clutter Signals

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop, demonstrate, and validate a quantitative Inquiry Signal to Soil to Detector (ISSD) model that is accurately predictive of the noise/clutter signals expected for a wide variety of soil types/conditions when using various inquiry signals. The focus of this topic is on the development of innovative prototype signal processing methods to enhance mine/UXO sensor performance and, as such, success would result in a critically enabling technological capability.

DESCRIPTION: Detection, location, and accurate identification of buried mines/unexploded ordnance (UXO), without resorting to extensive excavation, has always been difficult because of the lack of a quantitative, accurately predictive, and widely applicable model of the interaction of inquiry signals with the soil, and then with a detector. With such a model that accurately predicts and quantitatively characterizes the noise/clutter expected from any intended environment, it will be possible to greatly improve the signal-to-noise (S/N) ratio of any sensor system. The associated benefits include an enhanced detection capability while also reducing the "false positives" (i.e., improving the assuredness of target identification). The inquiry signals include infrared, nuclear quadrapole resonance (NQR), other electromagnetic techniques including ground penetrating radar (GPR), chemical detection, and acoustics based methods. The soil component of the interaction model is intended to cover all naturally occurring soil types present on the surface and near surface of the earth. This includes all combinations of sand-silt-clay, organic matter, moisture, compaction, and inclusions (e.g., gravel, rocks, roots, voids, sea shells, bones, macro-level life forms, etc.). Owing to the difficulty of the problem this ISSD model should first be considered for a situation free of any targets. Next, the more difficult case of including differencing approaches and interactions with targets can be treated. For this topic the targets shall consist of one or more of: 1) anti-personnel mines, 2) anti-tank mines, and, 3) a wide variety of shallow UXO but typically with metallic casings. Burial depth ranges from shallow sub-surface to 20 centimeters (cm) below ground surface. Soil type and conditions are extremely variable. For landmines the characteristic size dimension ranges from 4.5 cm to 38 cm; the emphasis shall be on low-metal (1 – 100 grams (g)) within a non-metallic case varieties; the explosive fill is typically Trinitrotoluene (TNT), Royal Dutch (Demolition) Explosive (RDX), or cyclotrimethylenetrinitramine, and Pentaerythritol Tetranitrate (PETN); and fuse mechanisms can include pressure, tilt rod, magnetic influence, seismic/acoustic or other.

Much of the challenge and need for innovative thought associated with this topic involves creating a widely useable approach or framework that can easily encompass all of the applicable and potentially applicable variables for the various inquiry signals. Both active signals (i.e., purposefully introduced artificially) and passive signals (i.e., naturally occurring but still detectable) are to be considered. It is expected that, at a minimum, broad and incisive knowledge of the areas of physics, soil mechanics and chemistry, and signal processing will be needed.

PHASE I: Demonstrate a predictive model that accurately determines the expected noise/clutter signal(s) from two widely different soil types of various conditions (i.e., moisture, compaction, inclusions, etc.) for at least two types of previously specified inquiry signals. In all cases the specific source(s) of test data must be adequately specified. Sensor(s) employed must ultimately produce high quality data and be minimally prone to being plagued by artifacts of the hardware. Well characterized soil samples prepared independently may also be used for blind confirmatory testing.

Phase II: Extend the prototype ISSD model to all soil types and additional multiple listed inquiry signal types and fully validate the model's predictive capabilities. The offeror shall develop viable demonstration cases of mine/UXO sensor systems with improved S/N characteristics as a result of the ISSD model in collaboration with the government or private sector.

PHASE III DUAL USE APPLICATIONS: The offeror is expected to aggressively pursue commercial or government partners for implementation of the critically enabling capability represented by the ISSD model. In addition to mine/UXO, applications could include: tunnel location for military and/or counter-drug intervention efforts, missing-in-action (MIA) as well as native American grave location, contaminant plume characterization and monitoring for improved remediation and compliance with federal requirements, archeological and cultural artifact Phase II assessments (w/o disturbance), and utility location in an increasingly congested subsurface infrastructure.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: With an improved assured identification capability through better signal discrimination it may be possible to decrease by 50% the number of targets that need to be further characterized in more detail. For countermine efforts this would double the mobility, and for UXO twice the area could be covered for equal effort.

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3) A. Ephremides and B. Hajek, "Information theory and communications networks: An unconsummated union," IEEE Trans. Inform. Theory, vol. 44, pp. 2416-2434, 1998.
4) Dwight K. Butler et al. "Multisensor Methods for Buried Unexploded Ordnance Detection, Discrimination, and Identification", Tech Report SERDP-98-10, Sept 98.
5) Jose L. Llopis et al., "Site Characterization Investigations in Support of UXO Technology Demonstrations, Jefferson Proving Ground, Indiana", Tech Report GL-98-20, Sept 98.

KEYWORDS: signal processing, modeling, geosciences, soils, mine detection, UXO detection, identification, noise, clutter

A03-128 TITLE: Implementation of a Geospatial 3-dimensional Topology Model

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Combat Terrain Information Systems (CTIS)

OBJECTIVE: To design and develop a three-dimensional model of topology for inclusion into Geographic Information System Technology.

DESCRIPTION: As the world population grows and urban land is used with growing intensity, there is increasing emphasis to utilize space under and above the surface for such purposes as urban transit, employment centers, and high-density housing. With this focus, there is a need to develop and maintain computational models that master the complexity of three-dimensional relationships above, below, and across the land surface. Current Geographic

Information System (GIS) technology is based upon 2 dimensional (2-D) models of topology that detail and track connected spatial relationships between physical entities. Current GIS technology projects our 3-dimensional (3D) world onto a two dimensional plane to form topology. This limiting 2-D approach cannot begin to model the complexity of dense 3-D urban areas where 50% of the world's population is projected to live in coming years. This lack of a developed model of 3-D topology precludes our computational ability to perform accurate spatial analysis of objects above and below the earth, and with regard to their relation to the surrounding surfaces. Examples of potential applications enabled by the development of 3-D topology are: cellular communication tower location planning, complex building fire analysis, and chemical weapon dispersion models. Furthermore, the ability to visualize scenes from a 3-D perspective is constrained to being a "pretty picture" without computational ability to detect errors in 3-D geometry models or perform complex computational 3-D analysis operations.

The Government seeks the capability to store, manage, and use 3-dimensional feature data in concert with 3-D topological spatial relationships. The contractor shall either internally store 3-D geometry and topology within a GIS database or interface to a COTS GIS database through external data files and access methods. This shall be implemented in a manner to facilitate both transition to commercial applications and adoption by Government for uses in Homeland Defense and the Army Future Combat System. The solution must address problems and handle such 3-D features as tunnels, vertical cliffs, caves, and building interiors.

The Government seeks a contractor to investigate methods and develop software to implement a 3-dimensional topology software application.

PHASE I: The contractor will accomplish the following research goals: 1) develop and show feasibility of a conceptual design for storing and exploiting 3 dimensional topology, and 2) initiate development of key 3-D concepts and relationships. The contractor will provide a report documenting their conceptual 3-D topology design and algorithms.

PHASE II: The contractor shall develop and deliver an implemented 3-dimensional topology software application that interoperates with commercial geographic information systems. The contractor will demonstrate ability to model complex topology relationships, access topological primitives, and demonstrate these topological relationships between objects above, below, and across the land surface, in addition, to demonstrating system interoperability.

PHASE III: This SBIR would result in a technology with broad applications in the civil and military communities by providing a new unique commercial capability to model, access, and utilize complex 3-dimensional geospatial geometry and topology.

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KEYWORDS: 3 dimensional, topology, GIS
A03-129 TITLE: Spatial Data Mining

TECHNOLOGY AREAS: Battlespace

ACQUISITION PROGRAM: Combat Terrain Information Systems (CTIS)

OBJECTIVE: Army commanders need to quickly and accurately see, decide and act in order to have the advantage over future adversaries. In the DoD cognitive hierarchy, spatial data mining discovers relationships that produce information that results in knowledge through evaluation and analysis. The objective of this research is to develop tools for: a) discovering relationships from diverse sources of spatial data that will provide or predict essential terrain features and attribution, and b) predicting patterns based on observation of dynamic spatial behavior (troops, snipers, weapons, on- and off-road vehicles, etc.). Meeting this objective is important for the intelligence preparation of the battlefield (IPB) for the Future Combat System (FCS). These tools will make it possible to see relationships in complex datasets which could not be seen in a reasonable time, or perhaps ever, by operators simply looking at the data. Data mining is included as a tool in the FCS Situational Understanding Specification.

DESCRIPTION: The Army seeks to develop automated spatial data mining techniques that will provide information superiority to the warfighter. Army commanders need to see, decide and act in order to gain and maintain advantage over future adversaries. In the DoD cognitive hierarchy, spatial data mining provides relationships that are used to derive information that, through evaluation and analysis, results in knowledge. The commander then uses this knowledge to gain understanding that is used to decide and to act. The Army, Homeland Security, and the commercial sector will use the relationships derived through spatial data mining to rapidly predict, augment, and verify information, as well as to detect errors.

Army systems need terrain data at a greater fidelity than is provided by NIMA's Country Database. To achieve greater fidelity, additional terrain information is needed in the form of a Mission Specific Data Set (MSDS). Spatial data mining will assist in achieving the needed fidelity. Examples of capabilities essential to the Future Combat System (FCS) which require greater fidelity than are provided by the Country Database are Tactical Decision Aids (TDA's) and detailed mission-planning and rehearsal.

Manual extraction of essential attribution and features is a labor-intensive process. The Army seeks to develop automated spatial data mining techniques that discover relationships among diverse sources of spatial data and that use these relationships to discover attribution and features, needed in a MSDS, that are not found in the Country Database. Examples of essential mission-specific terrain features and attribution that are not found in the Country Database are soils, streams, cropland attribution, grassland attribution, and urban attribution.

As an example of spatial data mining applied to the battlefield, a commander needs to decide the best approach to a military objective such as an unfriendly command center. In this case, spatial data mining tools will provide information of greater fidelity to the TDAs that will improve the commanders understanding of terrain, trafficability, cover, slope, distance, predicted weather, troop and weapons movement, air cover, and firepower. This enhanced understanding will enable the commander to make improved maneuver decisions.

As an example of spatial data mining applied to Homeland Security, a sniper is terrorizing a metropolitan area in a manner that has an obvious spatial component. Spatial data mining techniques automatically detect behavior patterns, predict future sites of activity, and narrow the list of suspects.

Key scientific challenges revolve around the discovery, enumeration, and digital encapsulation of relationships between differing components within our physical spatial world. The proliferation of geospatial data holds the promise of having many representations of attributed feature data over the same physical location, either in vector or raster form. Little use has been made of the relationships that might exist among all data sources that exist over a particular location. Relationships can be viewed as vertical, looking down at all data over a location, horizontal, looking at spatial relationships such as adjacency that exist in one or more data sets, or time-related, looking at the change in position of entities within the spatial domain. Spatial data mining seeks to discover the vertical, horizontal, and temporal relationships that exist among various sources of spatial data and to use these relationships to discover useful information.

The primary emphasis of this research should be to develop spatial data mining tools for terrain features and attribution. However, proposals encompassing spatial data mining applied to dynamic situations are also encouraged.

The Army seeks the capability to discover relationships among co-located spatial data and to use these relationships to predict or verify the occurrence of spatial features and their attributes. Spatial data mining makes explicit or implicit use of coordinates. This is not to be seen as an exercise in extracting features from imagery.

The Army seeks a contractor to investigate methods and to develop software to perform spatial data mining so that it can be quickly and efficiently integrated into Army systems. Emphasis is placed on predicting or verifying features and attributes, which are useful to the FCS.

The contractor must have the ability to interface with a geographic information system (GIS) to insure compatibility with both the commercial sector and with the FCS Lead System Integrator (LSI).

PHASE I: The contractor will develop a design, and demonstrate limited prototype software that predicts the occurrence of terrain features or attributes and/or the dynamic components within the terrain. The prototype software can use real or simulated data. The contractor will provide a report documenting the design, including the data mining algorithms and the discovered relationships.

PHASE II: The contractor will develop and demonstrate data mining prototype software and demonstrate the accuracy of the information it predicts. At the conclusion of Phase II, the contractor will demonstrate and deliver mature, robust spatial data mining software that is interoperable with a commercial Geographic Information System (GIS). Algorithms and methodologies will be documented so that they can be integrated into the Army systems.

PHASE III: This SBIR would result in a technology with broad applications in the civil and military communities by providing datasets of improved quality and resolution. The FCS would use spatial data mining technology for force deployment, intelligence preparation of the battlefield, and training. In the commercial sector this SBIR would be used for emergency management, community planning, and infrastructure development.

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KEYWORDS: Data Mining

A03-130 TITLE: Sensors for Rapid Chemical Biological Radiological (CBR) Detection and Countermeasure Activation to Protect Water Distribution Systems

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO CBD

OBJECTIVE: To develop technological solutions to support Physical Security Planning Area and prevent, isolate or mitigate chemical, biological, (CB) to water-based utility systems. To maintain water supply safety and health requirements by providing early warning capabilities to protect against CB threats to drinking water.

DESCRIPTION: Existing Department of Defense (DoD) installation utility systems typically lack consideration for counter-terrorism, do not have supervisory control and data acquisition systems (e.g., commercial sector Supervisory Control and Data Acquisition System (SCADA)), are not set up for alternate source or cross feeds/supply or do not have updated emergency response plans.

PHASE 1: Terrorist attacks on water based utility systems such as potable water, water based fire protection systems have the potential for greatest direct impact to personnel. The thrust of Phase I is to investigate and adapt novel sensors for use in detecting CBR threats to water based utility systems. The challenge is to identify and adapt innovative detector technologies that will survive and operate in a continuously submerged, high-pressure environment to provide a low cost, high reliability sensor to detect low contaminant concentrations. The sensor should be capable of detection levels on the order of 10 to the minus 12th to 10 to the minus 11th. The CB sensor based network would provide an effective early warning system and countermeasure/treatment activation for water-based utilities. Developed sensor systems should be compatible with commonly available SCADA and building automation systems.

In the Joint Service Agent Water Monitor Program, five general classes of detection technologies were identified: Classic analytical techniques, Optical Techniques, Polymers/Materials, Assays and Sentinel Species. Also identified are the new areas of MEMS (Micro Electro Mechanical Systems) and MOEMS (Micro Optical Electro Mechanical Systems) which rely on a concept proven in one of the other classes, but micro- and nano-structures are built based on the larger system. "Nano-materials" was incorporated into this area. Some example technologies are included below, but the call is not limited to those arenas. It is highly likely that a final capability will rely on a combination of sensor technologies integrated into the system.

Emerging integrated microfluidic devices are currently being used in biological system monitoring could also be applied to detect the presence of CBR agents in a waterborne environment. These on-die devices are typically constructed to survive and detect small chemical concentrations in liquid environments. The use of micro-needles could extend the useful sensor life by selectively limiting the molecular weight of molecules that reach the sensor. Integrated circuit based detectors would create a low cost sensor, allowing wide distribution and high reliability with sensor redundancy.

Sensors incorporating thin film organic light-emitting devices, or surface plasmon resonance also present a promising emerging technology for the detection of waterborne CBR agents. Another very promising emerging area is the use of chemically sensitive microspheres for chemical and biological detection. Monolayer and nano detector technology have been investigated with success in atmospheric environments, and could transfer to detectors in an immersed environment.

New strides in spectroscopy have been made in Raman, SERS (Surface-Enhanced Raman Spectroscopy), and IR (Infrared) spectroscopy in identifying CB analytes and the engineering of small field portable sensors. Also of interest are other sections of the spectrum such as RF (Radio Frequency) and mmwave (millimeter wave.)

The call should also take into consideration new and novel capture probes. Capture probes such as antibodies, genomic, protoemic, aptmers and engineered ligands ("smart ligands") are known, but new methods for improving sensitivity, selectivity are desired. Some of the emerging microfluidic devices depend on having working assays to incorporate. Performance of such systems will depend on having optimized reagents.

PHASE II: The Phase II effort will involve the design, construction and testing of the prototype advanced sensor for chemical and biological agent detection developed in Phase I. Phase II award will be based on the successful Phase I detection of simulant agents in a water environment at the detection levels required. The testing of the prototype sensor will be conducted on a scale closed loop model of a typical DoD or Army water based utility system containing controlled amounts of actual chemical or biological agents at an Army laboratory that is designed to handle chemical and biological agents. Prior to system testing, guidelines would be developed for applicable sites, operating procedures, monitoring, installation methodology, reliability monitoring and removal efficiency. After the pilot testing, guidelines would be developed and incorporated into a user guide.

PHASE III DUAL USE APPLICATIONS: The Phase III effort will involve further sensor demonstration and validation for transition to the marketplace. CBR Sensor and response technologies developed in this topic area have the potential application to municipal water distribution systems, water reservoirs, industrial/institutional complexes, universities, and military bases. Such technology is closely related to the emerging market of smart water systems which are capable of autonomously maintaining water chemistry. Increased water security would be a great value added component to augment any SCADA system.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Water storage and distribution networks present a tremendous vulnerability that is difficult to protect. This Small Business Innovative Research (SBIR) has the potential to save civilian and military lives as part of an early warning system protecting drinking water storage and delivery networks. The importance of effective and low cost CBR detection for domestic systems has increased dramatically since the events of 9-11. Sensors are needed to meet this need.

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KEYWORDS: microfluidic sensors, thin film sensors, micro needles, chemical agent detection, biological agent detection, utilities systems, force protection, SCADA, MEMS, MOEMS

A03-131 TITLE: Immunological Detection of Pathogens by Biofunctional Membrane

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: The objective of this SBIR is to design and build a small portable biofunctional device that can be taken into the field by soldiers to monitor streams and effluents for the detection of biological agents, and will be integrated with global positioning to provide critical time and location information. Remote placement of sensors and detection of contaminants is desired.

DESCRIPTION: There is a need for near-real time detection and location of waterborne biological agents in small quantities by the warfighter. Remote placement of sensors and detection of contaminents is desired. Since surface water is the primary water source for field soldiers, there is a critical need to determine the extent of potability, especially in undeveloped countries. One approach for developing this detection system could include use of a membrane within a chamber wherein probes or protein-antibodies are adhered to the membrane for use in pathogen detection. The probe, for example, could be a fluorescent probe, but is not limited to fluorescent illuminated detection. The active site on the membrane containing the adhered probes would be in contact with the flow of water or surface solution moving through the chamber where, upon contact with biological pathogens or pathogen indicators, the adhered probes would trigger a response for remote interrogation. The research in this effort will consist of membrane and probe development and their integration within a chamber for field deployment. The membrane may also be quickly assayed or interrogated using traditional methods of spectrofluormetry, mass spectrometry, chromatography, etc? In Phase II, integration of global positioning with the membrane chamber will permit the location of a detected agent to be mapped and monitored.

PHASE I: Complete a conceptual design and demonstrate feasibility of a biofunctional membrane pathogen detection system. The concept design should include the target proteins, antibodies, and probes; the membrane upon which they are attached; and the chamber in which they are incorporated. Chamber design will also include power supply, component integration, and means of dispersal and signal recognition. As part of feasibility demonstration, it would be desirable to include tests of signal/probe preparations required for the detection of select pathogens and/or pathogen indicators.

PHASE II: Develop and demonstrate prototype system. Test under a range of controlled effluent releases of surrogate agents. Apply different analytical procedures for elucidating ?harvested? tagged antibody-probes. Integrate global positioning with the unit for locating, time-stamping, and mapping detected agents. Time stamping should provide the needed information for monitoring pathogen flows and dispersal rates.

PHASE III DUAL USE APPLICATIONS: Such a device has broad dual use applications from monitoring environmental water quality for drinkable water to expanded military uses including non-man portable shore monitors. Additionally, drones may be adapted to distribute and monitor the chambers remotely.

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KEYWORDS: Biofunctional membranes, fluorescence, antibody, site-specific immobilization

A03-132 TITLE: Modeling and Simulation of Chemical and Biological Agents in Potable Water Systems

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To develop modeling and simulation algorithms and software capable of predicting the transport and fate of chemical, biological, radiological (CBR) contaminants in a potable water system as well as provide an analysis of agent interaction with conventional water treatment, such as chlorine. This tool would be used to compliment existing Army modeling and simulation tools for hydraulic flow within a water distribution system. Laboratory evaluation and pilot testing at select Army facilities would be conducted to introduce simulants to this innovative modeling and simulation tool. This software must be object oriented and windows based.

DESCRIPTION: Existing Department of Defense (DoD) installation utility systems typically lack consideration for counter-terrorism. In the event that a waterborne contaminant is detected in the system, it is critical to know how these agents would transport through the water supply, as well as how they would react to conventional treatment. Many installations lack the technology needed to model and simulate contaminant flow, and therefore do not have an effective CBR response plan in place. What is needed is advanced modeling and simulation algorithms and software that can predict the behavior of chemical and biological agents within a water system. This would allow for appropriate response and countermeasure procedures to be determined.

PHASE I: Develop the most appropriate dynamic modeling and simulation tools capable of meeting the following requirements. This tool must contain the algorithms necessary to perform a vulnerability analysis (including identification of critical access points), to predict the transport and fate of CBR contaminants in a potable water system, incorporate agent interaction with conventional treatment techniques, determine the location and type of CBR sensors required to ensure water safety, and develop models of the CBR agent/pipe wall/water interface. The interface modeling should include the interaction of the agent with corrosion or scale deposits (i.e., roughness) on the inside surface of the pipe. Phase I will result in the version one software, which would be pilot tested in Phase II.

PHASE II: The pilot testing of version one software which includes the dynamic model and simulation and algorithms to predict fate and transport of agents would be conducted within a closed loop test facility. After successfully validating the version one software on a closed loop, a full-scale pilot test at an Army facility would be conducted to evaluate the accuracy and response time of the dynamic model.

PHASE III: Demonstration and validation of the modeling and simulation tools would then be conducted. Guidelines will be developed for applicable sites. This will include operating procedures, monitoring, installation methodology, reliability monitoring, and design efficiency. Such highly innovative algorithms and software have potential application to any number of local municipal systems, universities, industrial complexes, and military installations. The evaluation of the commercial product would be performed in this phase.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Proposed research allows for efficient determination of CBR emergency response plans, as well as vulnerability and risk assessment analysis. As this is a tool used primarily in determining a course of action to prevent loss of human life, the cost savings is invaluable.

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KEYWORDS: chemical weapons, biological threat, potable water utilities systems, force protection, modeling and simulation

A03-133 TITLE: Geospatial Exploitation of Motion Imagery (GEMI)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The Army needs the capability to incorporate motion imagery (including near-real-time video) into battlespace intelligence tools for the Future Combat System (FCS). The Geospatial Exploitation of Motion Imagery (GEMI) objective is to develop tools for extracting time-based feature attributes from motion imagery of all kinds, and to provide the necessary links and standards for their incorporation into existing geospatial intelligence tools. Existing systems have difficulty extracting time-sensitive information and accurately depicting it within baseline battlespace intelligence information formats. The objective of this research is to close that gap. Accurate and timely depiction of time based geospatial information is essential to the intelligence component of the FCS.

DESCRIPTION: GEMI focuses on exploiting the temporal dimension of tactical motion imagery and related sources to enhance geospatial products with respect to time and location. The research must address the problem of extracting essential time-related geospatial information for small areas of interest from large data sets by leveraging metadata imbedded in the motion imagery stream. Although the primary interest is in motion imagery collected from airborne collection platforms, motion imagery collected via both surface (terrestrial and water) and subsurface (underground, underwater, and indoors) also merit consideration. Most motion imagery of interest is from vehicle-mounted platforms, but some handheld and fixed position sites offer potential temporal geospatial value. However, imagery and supporting metadata that fails to conform to the National Imagery and Mapping Agency (NIMA) Motion Imagery Standards Profile (MISP) and the MPEG-2 Standard (Motion Picture Expert Group) is of limited interest.

The research will identify specific geospatial and terrain features that exhibit an inherent temporal dimension amenable to motion imagery exploitation. Possible examples of military significance might include: highway traffic patterns at different times; river and stream flow behavior at different water levels; operating characteristics of key line-of-communications (LOC) features (drawbridge, canal lock, dam, etc.); and characterizing human, animal, and vehicle movement with respect to terrain, obstacles, and choke points. The expectation is for the research to develop means of understanding time dependent activity by exploiting time dependent geospatial information.

Research may draw from both military and relevant civil traditions (journalism, wildlife management, soil science, law enforcement, hydrology, irrigation, traffic management, geography, etc.). The research must address the realities of existing fielded computer environments and their limitations in handling large data volumes with limited bandwidth, storage, and processing capabilities. Research should target commercial progressive scanning cameras (720P or better optimum, 480P sub-optimum minimum) while accommodating imagery of either greater or lesser quality. The research must address the implications of motion imagery time and position error budgets.

At least one Army topographic unit experienced considerable initial success in using motion imagery in feature attribute classification. The exercise used motion imagery collected from a rotary-wing aircraft platform for road classification. In addition, the improving commercial market for motion imagery cameras and computer video editing capabilities, not to mention the maturing military UAV motion imagery collection platforms, makes it an opportune time to systematically seek out means to exploit the temporal dimension of motion imagery. The objective of this SBIR topic is to benefit Army topographic units by conducting the research and development necessary to accurately and efficiently exploit the temporal dimension of motion imagery and develop interfaces between its products and existing geospatial information tools.

Depending on the topographic features of interest, the amount of motion imagery involved varies considerably. In some cases we are talking about a few isolated clips. In others, it may be necessary to collect minutes, if not hours, of imagery extending over multiple missions over extended time periods. The advantage of using motion imagery (when it can be collected) in defining terrain feature attributes includes the fact that it can be of higher resolution and lower cost than current commercial satellite imagery. In addition, it offers the choice of multiple observation angles and over-feature dwelling time that simply is not available with more traditional overhead mapping imagery.

PHASE I: The contractor develops a conceptual approach and demonstrates feasibility. During this time the contractor must show how his research will enhance and expand existing motion imagery capabilities in current use by Army topographic terrain units, military intelligence units, and NIMA.

PHASE II: The contractor develops and demonstrates a deployable prototype.

PHASE III: This SBIR would result in a significantly enhanced capability for obtaining geospatial information from motion imagery. This product would have broad application in both military and commercial communities. Military applications could include intelligence preparation of the battlefield (IPB), terrain mapping, and other terrain intelligence uses supporting the FCS. Commercial and civil applications could include homeland defense, journalism, wildlife management, soil science, law enforcement, civil engineering, agriculture, forestry, hydrology, irrigation, traffic management, geography, utilities management, mining, and urban planning.

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KEYWORDS: Motion Imagery, Geospatial, Terrain, Topography, Geography, Knowledge Management, and Learning Organization.

A03-134 TITLE: <u>Dendrimers for Biological Warfare Agent Detection and Neutralization for Immune Buildings</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective of this research is to synthesize polymeric materials containing dendrimers, which are capable of neutralizing biological warfare agents in building Heating Ventilation and Air conditioning (HVAC) systems. The effectiveness of the material would be demonstrated by exposing the material to a biosimulant, such as dispersed Bacillus Globulli (BG) Spores and followed by monitoring culture growth.

DESCRIPTION: This effort would involve synthesis of dendrimers that can be used to detect and neutralize biological warfare agents. The dendrimers, containing entrapped biological passivating agents and equipped with agent-detecting component(s), would be incorporated into materials that can be used as liners or filters for HVAC systems. The release of passivating agents may be triggered upon binding of the biological warfare agent to the dendrimers followed by activation of the catalytic mechanisms by the specific functionalities available on the surface of dendrimers. The dendrimers would neutralize the biological warfare agent by releasing a passivating compound, which should be stronger than the currently used chlorine dioxide.

PHASE I: Identify the ability of novel dendrimers, containing detecting and passivating entities. Determine the feasibility of incorporating dendrimers into materials that can be used for detecting and neutralizing biological warfare agent or their surrogates in immune building HVAC systems.

PHASE II: Test and demonstrate materials containing dendrimers that can be used to detect and neutralize biological warfare agents in building HVAC systems to enhance their immunity to internal or external biological warfare agent release. Characterize the effectiveness of the materials after swiping the exposed surfaces followed by negative culture growth in a simulated environment.

PHASE III DUAL USE APPLICATIONS: Military and civilian buildings, such as command/control centers, will be far less attractive targets for attacks by airborne/aerosolized biological warfare agents, when augmented with the capability for the detection and neutralization of biological warfare agents. The application of detection and neutralizing chemicals to building infrastructure will greatly reduce the effectiveness of any such attack.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: There is a potential for
cost reduction over currently used methods of detecting and neutralizing biological warfare agents by implementing dendrimer-based technology. Examples of conventional methods are: laboratory based tests that use the polymerase chain reaction (PCR) technique for detecting the presence of biological warfare agents, and the release of huge quantities of chlorine dioxide at the contaminated site for neutralization. By contrast, smart materials containing dendrimers could provide an on-site immediate detection and neutralizing capability, thus eliminating laboratory tests necessary for validation of contamination and increasing safety for all personnel involved. These materials could be used as liners or filters in immune building HVAC systems.

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KEYWORDS: dendrimer, materials, biological warfare agent, immune building, internal release, external release

A03-135 TITLE: Urban Tactical Decision Aids

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Combat Terrain Information Systems

OBJECTIVE: Design and develop urban tactical decision aid (UTDA) software that can exploit three-dimensional

(3-D) urban terrain data. Investigate urban combat lessons learned and be cognizant of emerging tactics, techniques and procedures to support urban combat. Demonstrate awareness of existing tactical decision aids (TDAs) and leverage existing capabilities. Where possible, adapt traditional terrain analysis tools, commercial geographic information systems (GIS), etc., so they are applicable to uniquely urban situations. The Army Topographic Engineering Center's (TEC?s) Urban Tactical Planner (UTP) and the Army?s Combat Terrain Information Systems (CTIS) program might provide sources of inspiration. Development paths might entail popular GIS products and their associated plug-ins and programming toolkits. Using such tools, adapt and expand CTIS-like functions to the urban milieu, resulting in automated urban terrain analysis and visualization capabilities to support decision making.

These new UTDAs will ingest, analyze and visualize multiple layers of 3-D urban terrain data as well as 2-D data. The software will evaluate the impacts of urban terrain and help commanders make decisions regarding mobility, fields of fire/observation, obstacles, cover/concealment, fire hazards, command and control, etc. Possibilities include using available urban geometry data and information on building materials to facilitate selection and deployment of weapons, incorporating unique 3-D urban terrain data into troop mobility modeling, etc.

DESCRIPTION: Urban warfare has been called 3-D warfare and the great equalizer. The U.S. military?s overwhelming technological advantages are to some extent stifled in cities, where buildings shelter enemy forces from reconnaissance, and the presence of civilians makes the use of even the smartest bombs much more difficult. Ground forces will need to address the associated challenges that the urban conflict environment includes, from decreasing standoff and minimized high-technology advantages to increasing difficulty in avoiding collateral damage. Urban warfare has been considered so potentially costly that U.S. tactical doctrine has advocated isolating and bypassing urban areas wherever possible. However, adherence to these precepts, though valid, is becoming increasingly difficult as inexorable urban sprawl continues to change the face of the battlefield. The U.S. military needs to minimize the equalizing effect of urban combat. The commander faced with urban combat will benefit greatly from TDAs that are designed specifically for urban situations.

Terrain analysis has always been fundamental to offensive and defensive planning on any battlefield. Traditional TDAs help commanders to understand battlefield terrain and to make decisions based on operations such as line-of-sight calculations. However, it is likely that many - if not most - future military operations will have an urban component, as cities have become the primary sanctuaries of many of our contemporary and emerging threats. As a new terrain feature, the modern city tends to magnify the power of the defender and rob the attacker of advantages in firepower and mobility. Closely packed buildings, basements, alleyways and sewer systems offer cover, concealment and ready-made defensive positions to defenders. The urban setting is a complex and difficult environment in which to operate, and urban combat remains a special challenge. Tactical terrain analysis has traditionally considered some elements of the urban environment, but the focus has been on natural terrain elements. Increased awareness of the effects of manmade features on the overall tactical scheme is necessary. How urban terrain elements impact operations is an important consideration in determining tactical options. The physical layout of built-up areas and the structural characteristics of buildings represent critical planning considerations for the tactical commander.

Manmade construction impacts the tactical options available to commanders. Thus, commanders must treat urban elements as terrain and know how this terrain affects the capabilities of their units and weapons. They must understand the advantages and disadvantages of urbanization, and its effects on tactical operations. Since urban operations might require that soldiers fight for every corner, set of stairs, vending machine and hallway, a UTDA should describe at a tactical scale the layout of a city, including information on buildings, roads, railroads, bridges, underground infrastructure, and other features typical of urban areas. UTDAs should address concerns such as urban mobility, cover/concealment, perimeter defense, vulnerability assessment, fire hazards, fields of fire/observation, obstacle avoidance, coordination of fire/maneuvers, battle damage assessment, etc. Urban operations require 3-D information (building heights, the presence of underground facilities, etc.); thus, UTDAs need to be able to consider and exploit 3-D information. For example, commanders face the challenge of line-of-sight limitations imposed by urban geometry, so UTDAs must assist the commander in understanding and overcoming these limitations.

A UTDA could address issues such as weapon/munition selection, the effects of such selections on the urban environment, etc. It could identify types of buildings and help commanders understand the effects of weapons that might be used against these buildings. For example, masonry buildings tend to muffle the blast effect of the attacker?s artillery, and when destroyed, these buildings tend to choke the streets with rubble and broken glass. Urban commanders also need to be aware of public buildings such as hospitals, clinics, shelters, stadiums, parks, schools, etc. Which buildings, rooftops, intersections or other urban terrain provide observation and fields of fire? Which buildings pose fire hazards? A UTDA could identify key urban terrain and fields of fire, assist in developing movement plans toward objectives, provide locations of command and control nodes, recommend urban-specific supply items (ladders, knee and elbow pads, ropes with grappling hooks), etc.

A UTDA could perform aperture analysis. This would enable a commander to determine the number of apertures (windows, doors, holes due to weapons effects, etc.) in a given building. Depending on the mission at hand, an aperture might need to be suppressed, or it might provide a point of entry or exit. Based on aperture information and building composition, a UTDA could assist the commander in choosing the type of weapon needed to suppress and breach a given aperture.

An urban commander needs to know the streets, alleys, through-building routes, and subterranean passageways that can provide avenues of approach and mobility corridors. Subterranean passages provide covered and concealed routes of movement throughout urban areas. Ideally, a UTDA would provide information on the nature and location of subterranean features such as sewer systems, subway lines, underground garages, utility tunnels, etc. A UTDA could also identify elevated railways, mass transit routes, fuel and gas storage facilities, electric power stations, canals and waterways, airfields, etc.

PHASE I: Create a design/framework for UTDA software and show feasibility.

PHASE II: Develop and demonstrate prototype UTDAs for a range of urban environments, situations and conditions.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications where consideration of urban terrain is necessary. These applications might include security planning, assessment, and training (facility vulnerability analysis, critical infrastructure protection, security for event planners); command center operations (police force asset management, emergency management and response, city-wide situational awareness); and urban and transportation planning (land use analysis, traffic flow simulation, urban renewal projects).

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KEYWORDS: Urban, tactical decision aid, 3-D, GIS, analysis, visualization

A03-136 TITLE: <u>A Device for Estimating Site Condition</u>

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The objective is to design, develop, fabricate, develop parameters, and demonstrate a portable device which will quickly and quantitatively determine the site condition in terms of Erosion Potential/Training Capacity/Trafficability.

DESCRIPTION: Department of Defense (DoD) is responsible for administering over 25 Million acres of land. Mission activities vary greatly in their distribution and intensity across the landscape. Understanding mission related impacts is critical to assessing the potential for any particular activity to create a negative impact on the land, such as erosion contaminating water or air and decreasing the future capacity of the land to support training. DoD natural resource decision-making, modeling, and simulations technologies require a quantitative assessment of the lands character and capacity to sustain vehicle traffic. The ability to assess larger areas would be advantageous because training maneuver areas on Army installations are generally several thousand acres in size.

The erosion potential of a site will vary with time of year, amount of vegetation, percent bare soil, slope, soil moisture, weather conditions, soil type, soil density as well as the type of vehicle, the speed, and the straightness of the path. Currently sites can be assessed with a variety of devices and trained personnel, but the process is time consuming, and difficult to compare between sites and among sampling personnel. While much research has been completed that documents erosion potential factors, a composite system of parameters and detection devices does not exist.

The erosion potential/training capacity is equally matched by the trafficability or the ability of the land to sustain vehicular traffic. This area can also be important for military campaign planning and route selection on the battlefield. Sites with high trafficability typically have high training capacity and low erosion potential.

The system of software and hardware should be a vehicle mounted or hand-held device for determining the erosion potential of a site. This device should be able to detect the green vegetation, the mulch layer, bare soil, soil roughness, and bulk density for use in either derived or a composite of existing algorithms for determining erosion/ carrying capacity/trafficability potential of a site approximately 100 square meters or more in size.

PHASE I: Conduct an evaluation of existing and innovative commercial technologies for determining the properties of soil, vegetation and topography, as well as: the integration of these properties into an assessment of site condition, the miniaturization of components, and the transfer of data to the user. Prepare a preliminary design based on the technology evaluation and assessment of the available and/or derived parameters. Design should include, at a minimum, the specification of components, assembly, interface and control software, estimated costs, packaging, and estimated component size and weight. Design should include documentation of the trade-offs made during the design process and the parameters for translating device outputs to site condition. Develop appropriate software to estimate site condition and allow for output to a data-logging device.

PHASE II: Prepare the final design and construct a full-scale prototype of the system. The prototype will be evaluated for its design, construction, efficiency, packaging, and overall system performance. The system will be demonstrated in land conditions determined by the monitoring agency. Demonstration environments will include several sites with widely varying conditions and extremes of vegetative cover, soil moisture, and topography. The prototype will be refined as deemed necessary based on the results of the field demonstrations. Documentation will be prepared to define the techniques, procedures, applications, and limitations of the developed system.

PHASE III DUAL USE APPLICATIONS: This Small Business Innovative Research (SBIR) could aid in the assessment of public lands in whether to allow off-road travel. Companies that maintain remote sites could use it to assess the capability of unimproved roads to sustain travel. The environmental community could use it to estimate the potential for erosion from vehicular activities of many sorts. It could be used by high-end sport utility vehicle users to assess the advisability of off-road travel. Phase III consists of the commercialization of a system for military and commercial markets.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The Army presently spends about $40 million per year on land rehabilitation and maintenance. Perhaps as much as 30% of these funds could be saved annually by avoiding vehicle traffic on the most susceptible/ least trafficable sites.

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4) Field Manual, No. 5-430-00-1; Air Force Joint Pamphlet No. 32-8013, Vol I, Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations?Road Design ? Chapter 7 ? Soils Trafficability.

http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/5-430-00-1/toc.htm

KEYWORDS: land capacity, environmental impact, trafficability, erosion

A03-137 TITLE: Void Detection and Stiffness Measurement System for Road and Airfield Pavements

TECHNOLOGY AREAS: Materials/Processes

Objective: Design and build the hardware and software components for a portable system capable of measuring pavement strength/stiffness from a moving platform. The measured stiffness would be used to: 1) locate areas with potentially hazardous voids, 2) identify weak sections of pavement that would pose a high risk for catastrophic failures, and 3) aide in the determination of the pavement load carrying capability.

Description: Recently, several accidents have been reported involving aircraft punching through pavements on DoD airfields. An investigation also identified a number of additional pavement failures that would most probably have resulted in additional accidents had they not been visually detected. The predominant cause of these failures was determined to be the result of soil erosion along drainage structures beneath airfield and road pavements. The current state-of-the-practice for void detection involves the use of a heavy weight deflectometer (HWD) in combination with visual surveys and cone penetration tests. For testing, the trailer mounted HWD is positioned over a test point, a load plate is lowered to the surface, a weight is hydraulically lifted and released, and the resulting dynamic load and surface deflections are recorded. Only voids in very close proximity to the HWD load plate can be detected. Therefore, it is not feasible to conduct routine void detection assessments of entire airfields or road networks using these discrete measurement techniques. Recent developments in rolling deflection equipment have produced some equipment that may have potential, however, these devices are large, slow, and/or not fully validated with respect to accuracy. There is an urgent need to identify state-of-the-art testing technology with potential application to a continuous deflection measurement system from a moving platform. This system is needed to provide the technology necessary to periodically survey DoDs many thousands of square feet of aging horizontal infrastructure.

This system is also needed in support of DoDs force projection/deployment missions into austere areas with extremely marginal pavement infrastructure. As we deploy, both our aerial ports of embarkation and host nation aerial ports of debarkation will be essential for rapid decisive operations of the Objective Force. These aerial ports of debarkation will be the intermediate staging points and will require large numbers of heavy cargo/transport aircraft. Our force projection requirements will far exceed many of the NATO/host nation day-to-day missions, both in magnitude of wheel loading and number of operations. The Navy reference summarizes some of the pavement failures in the U.S. that have been attributed to aging sub-surface drainage structures. Fortunately, these failures have not occurred during a critical deployment scenario. But, it illustrates the type of problems to anticipate with aging infrastructure. As we plan for future deployments, we must consider the aging infrastructure of the host nations. Because many of their airfields are not being subjected to large numbers of heavy transport aircraft, we may not see a problem until we deploy. Failures of the sub-surface drainage structures often result in a catastrophic punch through. There can be considerable damage to the aircraft and pavement repairs can result in lengthy closure of the facility. An assessment tool is needed to rapidly and reliably assess the structural integrity of these airfields and identify potentially hazardous or weak areas that would hinder deployment of the Objective Force.

Phase I: The initial phase will consist of identifying innovative technology, conducting a feasibility investigation, and preparing a preliminary hardware/software design solution. Consideration should be given to accuracy, speed of testing, fieldability, and integration with existing military hardware/software for pavement assessment. The test equipment should be C-130 transportable and capable of operation in remote areas from a moving vehicle platform. The preliminary design must include an approximate cost of production, a description of any safety hazards, and an explanation of any availability issues related to equipment components. A final report documenting the design process and a formal presentation will be delivered to ERDC-APB upon completion of Phase I.

Phase II: The second phase will include the preparation of a final design solution and construction of a working prototype. Mid-way through the phase II effort, the prototype will be demonstrated to the ERDC-APB. The demonstration should include comparisons with results from traditional equipment such as HWD and pavement mounted instrumentation (LVDTs, velocity transducers, accelerometers). Upon successful demonstration of the first prototype, the hardware and software will be refined based on ERDC-APB comments and recommendations. A working prototype system will be fabricated and delivered to the ERDC-APB for testing, evaluation, and validation. Two weeks of training will be provided to ERDC-APB upon delivery of the prototype measurement system.

Phase III: A final prototype version of the measurement system will be fabricated based upon extensive evaluation by the ERDC-APB. All software, including source code, will be delivered to ERDC-APB for possible integration with existing DoD infrastructure assessment software applications. It is anticipated that the new technology will provide the DoD with a greatly enhanced measurement tool capable of reliably assessing (continuous measurement) the structural integrity of a pavement very rapidly from a moving platform. This equipment would be applicable for routine testing of roads and airfields in the DoD inventory and the expedient assessment of force projection platforms and road networks in the theater of operations. The highway community would also benefit from the successful implementation of this equipment. For highway testing, the continuous measurement capability is particularly desirable for safety reasons. Based upon the obvious dual use applications, a strong commercial potential is anticipated at the Federal, State, and local levels.

KEYWORDS: Airfield Pavements, Roads, Pavement Voids, Pavement Stiffness

A03-138 TITLE: High Temperature Matrices for Filament Wound Composites

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Tactical Missiles/KEM Project Office

OBJECTIVE: Develop a high temperature matrix for use in filament wound composites that is easily processed at room temperature. The matrix would be utilized in either "wet wind" or pre-preg form. The Army desires to have a high temperature matrix in order to reduce, and in some applications, eliminate the need for a thermal protective layer in flight weight missile and rocket applications.

DESCRIPTION: In current applications, resin systems used in filament winding that are capable of being processed at room temperature, or near room temperature, do not exceed a glass transition temperature of 250 degrees Fahrenheit. This relatively low glass transition temperature requires a layer of thermal protection to be applied to the outside of filament wound vessels in many missile and rocket applications. Applying this thermal layer increases weight and introduces secondary processing to the manufacture of filament wound composite motor cases. Higher glass transition temperature matrices are available, however they require processing at high temperatures to obtain viscosities compatible with the filament winding process. High temperature processing incurs costly modifications to filament winding equipment currently available throughout the industry. The high temperature matrix must have a glass transition temperature equal to or greater than 500 degrees Fahrenheit and be compatible with current fibers, such as carbon, Kevlar, and glass. This matrix must be easily processed at or near room temperature. The matrix would be utilized in either a "wet wind" or in a pre-preg fiber. The attainment of the required glass transition temperature presents a significant technical challenge.

PHASE I: Conduct a materials screening process to identify candidate matrix materials. Investigate compatibility of candidate materials with current processing techniques. Fabricate neat resin coupons for DMA testing and demonstrate target glass transition temperatures. Fabricate composite coupons and develop test method for demonstrating compatibility with commercial fiber sizings.

PHASE II: Define a representative pressure vessel for Phase II demonstration. Fabricate composite pressure vessels utilizing candidate materials, demonstrate compatibility with current processing techniques, demonstrate target glass transition temperatures, and conduct burst tests. Fully document materials processing and application techniques.

PHASE III DUAL USE APPLICATIONS: A high glass transition temperature matrix that is easily processed at room temperature 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 and 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.

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1) Peters, Humphrey, Foral, "Filament Winding Composite Structure Fabrication," 6th Edition, Society for the Advancement of Material and Process Engineering, 1991.
2) George P. Sutton, "Rocket Propulsion Elements: An Introduction to the Engineering of Rockets," 6th Edition, John Wiley & Sons, 1992.

KEYWORDS: Composite pressure vessels, Thermoset resin, Polymer matrix composite, Filament winding

A03-139 TITLE: Robust Alignment Concepts for Precision Guided Weapons

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO TActical Missiles, NLOS-LS Task Force

OBJECTIVE: Investigate utilization of low cost sensors and robust alignment algorithms to compute the instantaneous angular misalignment between the launch platform inertial reference and guided munitions to allow handoff of target coordinate information to the weapon prior to launch

DESCRIPTION: By 2008, the initial Future Combat System Objective Force will be fielded, and will fire multiple precision-guided weapons from remotely piloted airborne and ground platforms. Part of the Objective Force will be the container-launched NETFIRES missile. Development of modern extended range precision munitions requires accurate knowledge of the misalignment of the munitions navigation system with associated targeting systems for effective engagement. This is particularly true for such systems as the Precision Attack Munition (PAM) since it may be far removed from its targeting sensor in accordance with the NETFIRES operational concept. Achieving required alignment accuracies in a timely fashion has proven to be problematic. The use of mechanical tolerances to establish alignment is either impractical, difficult to achieve and maintain, and expensive. The application of dynamic transfer alignment methods has proven successful; however, current methods require the launch platform to undergo special maneuvers prior to munition launch. These maneuvers do not apply to ground launch systems, since the launch platform is to be emplaced for vertical launch without any provision for missile manipulation prior to launch. Traditional gyro-compassing methods for aligning stationary systems require inertial sensors that far exceed the in-flight performance requirements of the missile and would be prohibitively expensive. There is a need to develop an accurate alignment method that will provide milliradian accuracies given the benign dynamic environment of ground launch systems, but sufficiently robust to be applicable to airborne and ground launch platforms.

PHASE I: Investigate innovated concepts for determining misalignment between the precision guided weapon and the targeting reference. Evaluate the alternative concepts rank according to key performance parameters to include, but not limited to, accuracy, cost, size, and weight.

PHASE II: Select the best Phase I concept for determining misalignment and develop a design. The design will include a detailed model and simulation to evaluate performance. A laboratory experiment using prototype components shall be performed to data to validate the simulation and verify performance of the concept.

PHASE III DUAL USE APPLICATIONS: The alignment concept developed under this SBIR effort could be used in a broad range of military and civilian applications where computation of precise misalignment of an element with respect to an inertial reference is required. The most obvious military application is the alignment of missiles in weapon launchers to FCS NetFires launch platforms. Alignment allows for downloading of target coordinates and other mission essential data prior to launch. Non-military examples of spin-off are also plentyful. For example, large structures in space are non-rigid. These structures need to be dynamically aligned to maintain functional integrity. Also, new architectural building and bridge designs provide for flexible structures to absorb and resist naturally shocks from earthquakes or catastrophic events such as terrorist attacks. This technology can be incorporated in the structural design to provide control input for stability augmentation.

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1) Zarchan, Paul, Tactical and Strategic Missile Guidance, 2nd. Ed., AIAA, Washington, DC, 1994.
2) Garnell, P., Guided Weapon Control Systems, Pergamon Press, Elmsford, NY, 1985.
3)- Lee, R. G., et. al., Guided Weapons, Pergamon Press, Elmsford, NY, 1988.
4) Grewal, M. and Andrews, A., Kalman Filtering Theory and Practice, Prentice-Hall, Upper Saddle River, NJ, 1993.

KEYWORDS: weapon alignment, target handoff

A03-140 TITLE: Fabrication Enhancements for the Production of Spinel Domes

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Common Missile PMO

OBJECTIVE: Develop fabrication approaches for the production of low-cost transparent Spinel (MgAl2O4)2 hemispherical domes up to 6 inch diameter that meet the requirements for Dual Band Infrared seekers that are suitable for use in missiles, UAVs and other surveillance systems.

DESCRIPTION: Future requirements for Infrared sensors for both missiles, UAVs and other surveillance systems will require enhanced performance capabilities (Dual Mode Infrared) at lower cost. Although significant advances in electronics have led to many improvements in seeker technology, they have not been matched by improvements in the optical materials area. In fact, there has been no significant improvement since the development of sapphire almost 30 years ago. Sapphire is the state-of-the-art material for windows and domes for applications in the visible to Mid-Wavelength Infrared (MWIR) spectrum, where aero-thermal heating or erosion is an issue. Although it is currently the material of choice, it is expensive and the orthotropic nature of sapphire makes fabrication difficult for many optical applications, particularly for dome configurations. Spinel is one material that has the potential to meet future requirements due to its higher transmission in the MWIR, isotropic optical properties, and the potential for significantly lower fabrication cost. However, dome fabrication techniques have not been successfully demonstrated. The goal of this effort is to develop fabrication techniques and/or processes, (including reduction of processing temperature, pressure or time) to produce full hemispherical 6 inch diameter domes that will exhibit, at a minimum, the following properties: 84% transmission at 4.5 microns, 80% transmission at 0.7 microns, thickness of 0.180 inches and a refractive index homogeneity better than 100 ppm over the full 160 degree aperture.

While it is important to ensure that high optical quality of the materials is achieved, the fabrication approach must be scalable for generating up to 10,000 parts annually. Additionally, all processes and costs to produce a finished dome need to be considered.

PHASE I: Determine the feasibility of fabricating Spinel hemispherical domes of at least 160 degrees and up to 6 inches in diameter which approach or satisfy the transmission properties cited above. This determination should consider the basic mechanical and physical properties of Spinel and how the proposed fabrication process and techniques can be scaled to potentially achieve the production of greater than 10,000 finished domes per annum at reasonable costs.

PHASE II: Develop processing techniques and demonstrate prototype fabrication of multiple 6-inch Spinel domes of full hemispherical configuration. This demonstration should show batch-to-batch consistency for both transmission and mechanical properties. It should also show that the process provides uniformity in refractive index homogeneity better than 100ppm over the central 160 degrees. An estimate of preliminary production cost for annual quantities in increments of 1000 parts with a cost breakdown for blank fabrication and finishing is required.

PHASE III DUAL USE APPLICATIONS: The enhanced processes developed under this effort will provide low cost Dual Mode Infrared domes for sensor applications. These include missiles, UAVs and surveillance systems for military applications and security systems for sensitive buildings, facilities and/or installations for the commercial sector.

REFERENCES:
1) M. E. Thomas, R. L. Joseph and W. J. Tropf, "Infrared Properties of Sapphire, Spinel and Yttria as a Function of Temperature", SPIE vol. 683, 1986.
2) J. A. Cox, D. Greenlaw, G. Terry, K. McHenry and L. Fielder., "Infrared and Optical Transmitting Materials", SPIE vol. 683, 1986.
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KEYWORDS: Spinel, IR Windows and Domes, Hemispherical Dome, Low Cost, Production

A03-141 TITLE: Thermobaric Blast Pressure Gauges

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM, Aviation Rocket and Missiles

OBJECTIVE: To develop a fast response pressure transducer that has minimal response to outside stimulus. During Thermobaric explosions, the high heat and light caused by the blast can cause currently available sensors to give false readings. From past experience, we have found that thermal and photo stimulus can greatly impact the data received from these types of transducers. At the present time transducers with external cooling have had some success with the thermal effects but no success with the photoelectric.

DESCRIPTION: Virtually all pressure sensors are sensitive to thermal shock. When heat strikes the diaphragm of a pressure sensor that has crystals contained in an outer housing, the heat can cause an expansion of the case surrounding the internal crystals. Although quartz crystals are not significantly sensitive to thermal shock, the case expansion causes a lessening of the preload force on the crystals, usually causing a negative-signal output. Thermobaric reactions produce high thermal and photoelectric transients rendering present piezoelectric transducer technology inadequate for this application. The temperature ranges in question are from 1400 to 1600 degrees Fahrenheit or 760 to 870 degrees Celsius. These transducers need to be in the range of 50, 100 and 200 psi, with response rates around 1 microsecond. The transducer should exhibit minimal response when exposed to a broadband light source, which produces a radiant intensity of 10 milliwatts over the area of the transducer diaphragm.

PHASE I: Perform a feasibility study to see if a solution to the problem can be found.

PHASE II: After construction of the prototype transducer by the small business, testing at the Thermobaric characterization facility, located on the Redstone Arsenal, will be conducted at no cost.

PHASE III: These types of sensors could be used to quantify many new energetic materials that are being developed for urban warfare and current conflicts. There could also be a use for these sensors in the testing of rocket motors and boosters for both the military and civilian markets.

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1) Walton, W. Scott. ”Improvement of Air Blast Measurement, ILIR TASK 5”, March 1981 TECOM Project 7-CO-ILO-AP1-001.
2) “ An LTCC Hybrid Pressure Transducer For High Temperature Applications”, Jolymar Gonzalez-Esteves University of Puerto Rico.

KEYWORDS: sensors, energetic materials, transducer, piezoelectric

A03-142 TITLE: Weapon Weight Reduction Using Genetic Algorithms

TECHNOLOGY AREAS: Weapons

OBJECTIVE: The objective of this topic is to enable the Army engineer to design weapons that help meet the Future Combat Systems (FCS) initiative –weapons that are lightweight, portable, and lethal. This topic outlines an innovative strategy for reducing a weapon system’s overall weight using Finite Element Methods (FEM) and intelligent search algorithms.

Modern weapon design methods include the use of Computer Aided Design (CAD) and Computer Aided Engineering (CAE) software. A de facto CAE tool in the defense industry is Finite Element Analysis (FEA) software. FEA software is one of the most extensively utilized engineering tools in the Army. Practically every weapon system in the field today has been modeled at some point with FEA. FEA can model a weapon system’s reaction to mechanical and thermal environments – saving the Army millions of dollars that would have otherwise been spent on full scale testing. FEA is a fundamental and irreplaceable activity in the design of all future weapon systems.

Genetic Algorithms (GA) are computer algorithms that emulate the natural selection process occurring in the wild kingdom [1]. By predefining a set of traits for a given weapon system, the GA will search for an optimal combination of traits. These traits can be developed and evaluated using FEA along with relevant environmental conditions. This topic focuses on the trait of weight reduction with regard to mechanical and thermal boundary conditions. The Genetic Algorithm is an intelligent search algorithm that learns as it searches – hence it requires minimal human interaction once system traits have been defined. This behavior has the potential to dramatically reduce the design time for FCS weapon systems.

DESCRIPTION: It has been shown that weight reduction via shape optimization can be achieved using FEA , GAs, and B-Splines [2,3]. As geometry undergoes dynamic transformations in this automated process, sensitivity analysis can confirm that each transformation is mechanically viable and stable [4].

PHASE I: For Phase I efforts, contractor shall submit a software design proposal that integrates FEA and the GA for weight reducing arbitrary geometry. The proposal shall address the following design considerations:

The software shall be capable of working with Abaqus and Nastran 2D/3D continuum elements at a minimum. Software should contain an element library that users can add to. The software should work with any pre or post processor compatible with these codes.

- GA functionality shall be capable of distributed processing across computer networks using TCP/IP protocol.
- Software shall have a scriptable interface that exposes an Application Programming Interface (API).
- Software shall be invariant to the computer’s operating system (cross platform).
- Software should be able to transfer surface topology into CAD systems.

PHASE II: For Phase II activities, the contractor shall:
- Implement the software design proposed in Phase I.
- Demonstrate the software’s functionality and effectiveness.
- Deliver a copy of the source code and documentation.

PHASE III DUAL USE APPLICATIONS: Commercialization for this topic’s goals are excellent. FEA is used to design everything from contact lenses to office furniture. Weight reduction in many cases equals cost reduction in the manufacturing and transportation industries. Finite element analysis is a multi-million dollar industry and add-on modules that have optimization capabilities are an attractive investment.

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2) Annicchiarico, W. and Cerrolaza M., "Structural Shape Optimization 3D Finite Element Models Based on Genetic Algorithms and Geometric Modeling", Finite Elements in Analysis and Design 37, 2001, pp 403-415.
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KEYWORDS: Shape Optimization, Genetic Algorithm, Finite Elements, Modeling, Spline, CAD, CAE

A03-143 TITLE: Rocket Exhaust Plume Secondary Smoke Formation Modeling

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: CKEM PM

OBJECTIVE: To develop innovative models for the basic physical and thermochemical processes describing secondary smoke production in transient, two-phase, gas-particle, chemically reacting rocket exhaust plume flowfields which can supplement the existing models which currently limit plume interference modeling.

DESCRIPTION: Solid propellants which utilize ammonium perchlorate (AP) as an oxidizer, in particular those reduced smoke variants with low metal content, offer significant advantages over minimum smoke nitromene propellants for many tactical rocket motor applications. Beyond the safety, sensitivity, and mechanical properties, these reduced smoke AP propellants offer significant reductions in rocket exhaust plume afterburning with accompanying reductions in infrared signatures and a greatly improved environment for laser, microwave, and millimeter wave communications. However, reduced smoke solid propellants suffer one serious drawback which limits their use for tactical missile applications in that they can produce a secondary smoke or condensation trail in the exhaust plume under favorable conditions of temperature and humidity. The condensation mechanisms are reasonably well understood and simplistic rules have been formulated in terms of temperature and relative humidity which indicate whether or not secondary smoke formulation is likely to occur, but rigorous physics-based models for condensation in plume flowfields are inadequate at best. This shortcoming severely limits the ability to a priori predict plume laser interference for candidate solid propellant formulations and largely restricts those candidates to non-AP formulations for tactical applications.

Computational fluid dynamic (CFD) models are available, which account for the two-phase and finite-rate chemical kinetics processes in solid propellant rocket exhaust plumes with coupled body flowfields; however, these models, while very good, were intended to produce only quasi-steady snapshots of the missile flowfield along any point in the missile trajectory and then for only relatively short lengths as compared to the entire flight profile. Hence the modeling framework for the transient formation of secondary smoke must be developed with special consideration for the following:

1. The modeling architecture must incorporate the existing and extensive time-accurate, finite-volume, Reynolds-averaged, Navier-Stokes flowfield solution methodology including models for two-phase, gas-particle flows, and finite-rate chemistry.

2. The crucial role played by water and acid, e.g., HCl and HF, vapor mixtures in the formation of secondary smoke.

3. The relative roles played by water vapor available for condensation - either entrained from the external air

stream, produced as a rocket motor combustion product, or produced as product in an afterburning plume.

4. The role played by particulates as condensation nuclei - either ejected rocket exhaust particulates or aerosols entrained with the external air stream.

5. The time history for secondary smoke formation including condensation, agglomeration, dispersion and vaporization.

6. Field descriptions for condensate droplet size distributions throughout the plume.

7. Innovative solution techniques such that the required transient physical processes can be modeled while achieving solutions in a reasonable time period.

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

Technical approaches will be formulated in Phase I to address the problem area for later inclusion into computational fluid dynamic models utilized by the exhaust plume community. At least one innovative methodology will be coded and exercised during Phase I to assess the potential for Phase II success.

PHASE II: The additional model improvements formulated in Phase I will be finalized, documented, coded, and incorporated into an existing government computational fluid dynamics model for extended transient rocket exhaust plume flowfields. The improved computational fluid dynamics model will be run blind for a series of static solid propellant rocket exhaust plume test cases for which detailed infrared laser transmittance data is available to demonstrate the advanced capabilities for analyzing and modeling transient secondary smoke formation in rocket exhaust plume flowfields.

PHASE III DUAL USE APPLICATIONS: For military applications, this technology is directly applicable to all guided missile systems. For commercial applications, this technology is directly applicable to environmental analysis techniques for applications such as high speed supersonic transports and aerospace launch systems.

REFERENCES:
1) Terminology and Assessment Methods of Solid Propellant Rocket Exhaust Signatures, AGARD-AR-287, July 1993.
2) Tactical Missile Propulsion, V-170, AIAA Astronautics and Aeronautics Series, ISBN 1-56347-118-3/96, 1996.
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KEYWORDS: Rocket exhaust plume, Secondary smoke, Condensation, Two-phase, gas-particle flow, Finite-rate chemistry, Laser attenuation, Condensation nuclei, Solid propellant rockets, Computational fluid dynamics

A03-144 TITLE: <u>Nanograin MgF2 for Tri-Mode Seeker Dome</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Common Missiles

OBJECTIVE: Fabricate optical-quality, Magnesium Fluoride (MgF2) infrared-transparent windows with a grain size of 50 nanometers or less and mechanical strength at least twice as great as that of conventional MgF2.

DESCRIPTION: Conventional infrared seekers have been used for a number of years with great success. Many infrared dome materials have been developed for these applications. Millimeter wave guided missiles have also been very successful, again with a number of materials available for the radome. Efforts are underway to design the next generation of missile systems, which will require multi-mode seekers to improve standoff distances, provide all-weather capability, and allow for some degree of target recognition or aim point selection. Of particular interest are seekers combining both infrared and millimeter wave capabilities. Unfortunately, current materials for infrared and millimeter wave domes have conflicting characteristics. In particular, most infrared materials have very high dielectric constants compared to radome materials. Most radome materials are not transparent in the infrared. One material that does have desirable characteristics in both the infrared and millimeter wave region is MgF2. Magnesium Fluoride is currently available in both single crystal and polycrystalline forms. Both forms have a dielectric constant much closer to the typical radome material than most other infrared materials. Single crystal MgF2, however, is not strong enough to provide the required impact and erosion resistance. Polycrystalline MgF2, while much stronger, does not transmit in the near infrared band.

The goal of this effort is to demonstrate a nanograin MgF2 with the following properties: (1) Greater than 85% optical transmittance from 1-5 microns; (2) Total integrated optical scatter at infrared wavelengths (1-5 microns) should not exceed 2%; (3) Mechanical strength should be at least twice as great as that of conventional polycrystalline MgF2; (4) Thermal conductivity should not decrease from that of conventional material. Fabrication procedures used to make optical materials must be scalable to produce windows and domes up to 175 mm in diameter. Successful proposals will provide convincing rationale for how grain growth during densification will be prevented.

PHASE I: Conduct feasibility study and demonstrate a method to make fully dense, infrared-transparent material with a grain size of 50 nanometers or less. Infrared transmission should be within 2% of that of conventional forms of the same material. Specimens fabricated in Phase I should be at least 1 cm in diameter and 2 mm thick. The Government will measure total integrated infrared scatter at wavelengths of 1.06µm or 3.39 µm or both for up to 4 specimens fabricated at various times by the contractor. Powder samples should also be provided to the Government for pressing studies.

PHASE II: Optimize the fabrication process for the best tradeoff between maximum infrared transmission from 1-5 microns, minimum infrared optical scatter, and maximum strength. Conduct periodic measurements of transmission and mechanical strength to monitor the progress of process development. To aid in process development, the Government will measure total integrated infrared scatter at wavelengths of 1.06µm or 3.39 µm or both at times agreed upon with the contractor. Demonstrate scale-up of optical quality material to a diameter of 50 mm and a thickness of 2 mm. By the end of Phase II, measure the equibiaxial flexure strength at 25°C of 20 disks with a diameter of 25 mm and thickness of 1 mm. Measure optical properties of disks with a thickness of 2 mm. Powder samples must also be provided to the Government for pressing studies.

PHASE III DUAL USE APPLICATIONS: The number of multimode systems in use across DoD is increasing. Stronger, cheaper, higher performance materials are required to protect these sensors on aircraft and on munitions such as tactical missiles. Industrial applications requiring high temperature windows for process monitoring may also exist. Phase III will focus on developing the capability for high volume production of 175mm diameter domes for tactical missiles. In addition, applications in Navy and Air Force aircraft and missiles will be explored.

REFERENCES
1) D. C. Harris, Materials for Infrared Windows and Domes, SPIE Press, Bellingham WA, 1999.
2) http://www.konoshima.co.jp/en/yag.html
3) "High Power Nd:YAG ceramic laser," J. Lu, et al, Institute of Crystallography, Proceedings of the SPIE 4914, Oct 2002.

KEYWORDS: nanograin, infrared material, magnesium fluoride, missile dome

A03-145 TITLE: Weather Encounter Particle Impact Phenomena and Failure Criteria for Missile Components

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Air and Missile Defense/PEO Tactical Missiles

OBJECTIVE: Missile flight through adverse weather conditions can significantly affect system component performance and limit flight survivability. The objective of this topic is to conduct basic research into the weather encounter phenomena for ceramics typically utilized for missile radomes, windows, and leading edges. This research will provide a basic step toward the overall goal of developing and validating analytic design tools for increased system survivability and capability. Specifically, methods of analyzing and predicting failure will be developed for high performance silicon nitride, a typical high performance radome material, in supersonic environments traveling through weather phenomena such as rain and sand.

DESCRIPTION: Missile systems are generally desired to have ?all-weather? capability. This requires that all missile components survive and continue to function after exposure to environmental extremes such as rain, sand, and snow. The current method of designing ?all-weather? capability is to rely heavily on expensive empirical data to determine if missile components can maintain operability after exposure to these environments. As a result of the expense associated with these tests, they are often either greatly reduced or wavers are obtained to reduce the severity of the system requirement. Additionally, these expensive tests generally provide ?pass-fail? results due to the extremely limited understanding of the failure criteria for materials typically used in configurations exposed to weather encounter during flight. A significant shortcoming to the experimental process is the limited applicability to actual flight conditions. Weather encounter test facilities do not completely reproduce the environment of interest making the development of analytic methodologies critical. This topic would provide the initial step to developing analytic understanding of the failure criteria of ceramics and allow flight system design and optimization with minimized experimental validation. Additionally, the necessary design process will be identified to adequately validate system design in weather encounter environments. This will include the analysis process for radome weather encounter design, experimental validation, and specific failure criteria for the high performance silicon nitride radome material. The completion of the Phase I and II efforts is expected to identify and open even broader areas for future research in identifying and enhancing analytic methodologies, better rain resistant materials, and configurations having less susceptibility to weather encounter.

PHASE I: The focus of the Phase I effort is to assess the state of the art in weather encounter and survivability by performing an exhaustive search of existing analytic tools and methods, failure mechanisms and failure criteria for silicon nitride, and existing experimental data for silicon nitride which can be used as the foundation for the topic in Phase II. Under Phase I, the Government will provide weather phenomena definitions typical of army requirements such as rain rate (1-2 inch per hour) and droplet diameter distribution (1.5-6 mm diameter) as well as blowing sand rates and particle size, typical trajectories encountering weather, and configurations including angle of incidence and wall thickness definitions. The contractor shall identify existing constitutive properties and failure models along with any available test data for silicon nitride. The contractor shall identify in Phase I the deficiencies in analytic models and experimental data for silicon nitride and shall develop the Phase II program plan to address these deficiencies and conduct the necessary research and development to initiate a better analytic and experimental understanding of the particle impact failure behavior associated with applications to radomes.

PHASE II: The Phase II efforts will be devoted to analytic and experimental research to quantify the failure phenomena for high performance silicon nitride radome materials when subjected to a range of weather encounter environments typical of Army missile systems. This phase will involve the use of hydrodynamic and finite element codes as well as aerothermal boundary condition codes containing the ability to model weather encounter to develop the constitutive properties of silicon nitride defining the failure mechanism during particle impact. The analytic models will be validated and verified through the use of experimental methods for rain and sand impact on ceramics. The test procedures and test facilities are currently available at rain erosion test facilities like those maintained at AT&T Government Solutions (a non-government company) and possibly the Continuum Dynamics Supersonic Rain Erosion (SURE) facility being developed under a Missile Defense Agency SBIR program managed by the Air Force Research Laboratory. Subscale silicon nitride samples will be fabricated and experimentally evaluated collecting critical data necessary to develop and validate the analytic models. These analytic models are to include the dynamic response of silicon nitride due to particle impact and the relative constitutive properties to define failure thresholds. A by product of this analytic and experimental research will be the definition of the process required to characterize and develop any ceramic material for particle impact failure.

PHASE III DUAL-USE APPLICATIONS: The Phase III Dual Use for this topic exists in the increased understanding of particle impact phenomena on radome materials such as silicon nitride which promise to be the next generation missile radome materials. High performance radome material technology is currently being developed under Navy and MDA SBIR programs. Silicone nitride is a primary candidate for these applications because of its high temperature and high strength capability. However, these programs are concentrating on the manufacturing and fabrication constraints for next generation radome materials to reduce costs and increase reliability. This Army SBIR topic will complement these SBIR material development tasks by providing the necessary characterization and design model development for particle impact of silicon nitride and provide for significant leveraging, collaboration, and dual use opportunity. This Army SBIR will also initiate the research and development of analytic methods for designing and analyzing particle impact phenomena on ceramics. The same methods and experimental approaches represent roadmaps for research and development of particle impact phenomena on infrared windows and domes and brittle leading edges. These materials represent those used on high-speed missiles, commercial aircraft, turbine blades, and NASA/Air Force space plane research and development. Other material technologies such as ceramic matrix composites, composite airframes, and metal matrix composites can be investigated in future research using the same process as defined under this SBIR.

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3) A. A. Ranger and J. A. Nicholls. Aerodynamic shattering of liquid drops. AIAA Journal, 7(2):285-290, February 1969.
4) W. G. Reinecke and G. D. Waldman. Shock Layer Shattering of Cloud Drops in Reentry Flight. Technical Report 75-152, AIAA, January 1975.
5) W. F. Adler, ?The Mechanics of Liquid Impact?, Treatise on Materials Science and Technology, 16 (C.M. Preece, editor) New York: Academic Press, 1979, 127-183.
6) W. F. Adler and D. J. Mihora, ?Analysis of Waterdrop Impacts on Layered Window Constructions?, SPIE Proceedings, Vol. 2286: Window and Dome Technologies and Materials IV (Paul Klocek, editor) (1994).
7) W. F. Adler, ?Particulate Impact Damage Predictions?, Wear, 186-187 (1995) 35-44.
8) W. F. Adler, ?Waterdrop Impact Modeling?, Wear, 186-187 (1995) 341-351.
9) W. F. Adler, ?Rain Impact Retrospective and Vision for the Future?, Wear, 223-235 (1999) 25-38.

KEYWORDS: Particle Impact, Weather Encounter, Supersonic, Hypersonic, Reentry, Liquid Water Content, Particle Distribution, Hydrometeor, Hydro Code, Ceramics, Radomes, Infrared Windows and Domes, Ablatives, ATAC3D, Hydrodynamic phenomena

A03-146 TITLE: Coating Applications of Single Wall Nanotubes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To determine the potential of single wall nanotubes in increasing the effectiveness of military coatings and sealants in electromagnetic interference (EMI) shielding/grounding, durability, and corrosion resistance.

COORDINATION: This topic has been coordinated with John Escarsega of the Army Research Lab, and complements, rather than conflicts with or duplicates ARL projects.

DESCRIPTION: A well maintained coating system on military vehicles, weapons, and equipment is a significant component in battlefield survivability and effectiveness, thus contributing directly to battlefield lethality. Coatings impact the effectiveness of EMI shielding and grounding. In addition, coatings are a primary factor in the reduction of downtime due to maintenance as a result of corrosion and material degradation. Well maintained sealants are an integral component of the coating system.

PHASE I: Determine the characteristics of various admixtures of military coatings (paints and primers to include CARC) and single walled nanotubes with respect to EMI shielding/grounding. Determine the characteristics of various admixtures of sealants and single walled nanotubes for the enhancement of EMI shielding/grounding. Durability testing and determination of resistance to chemical agent, chemical agent decontaminants, and corrosive environments is required for the various components of the coating systems.

PHASE II: Conduct a feasibility study to determine the optimum tube size and coating/sealant compositions for various applications. Apply prototype coating systems to military equipment and test in various environments.

PHASE III: Enhanced coating systems will have many military and commercial applications. Projected uses are for military vehicles (ground, water and air), weapons system and ground support equipment, and commercial construction and heavy use equipment.

REFERENCES:
1) M. J. Biercuk, et al., Univ. of Penn, App Phys Ltrs, Vol. 80, No. 15, 15-Apr-2002.
2) Piche, Joseph W., Nanoshield Composite Electromagnetic Shielding for Hardening to Electromagnetic Interference and Electrostatic Dissipation, Summary of the Workshop on Structural Nanomaterials (2001), National Research Council (NRC).
3) Zhou, Otto Z. and Ajayan, Pulickel M.; Applications of Carbon Nanotubes, internet citation: www.rpi.edu/locker/38/001238/publications/Ajayan_Zhou10800391.pdf.

KEYWORDS: Nanotubes, coatings, sealants, corrosion, reduced reflectivity, EMI shielding/grounding

A03-147 TITLE: Impedance-Based Structural Health Monitoring

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Air Vehicle Comanche PMO

OBJECTIVE: A health monitoring and prognostic technique/system that can be implemented to give a real-time assessment of the structural health condition and to detect the presence of structural fault. From Structures and Dynamics Branch of Army Research Laboratory in the Broad Agency Announcement, 2000-2003, "From a structural dynamics standpoint, this work/research will help to understand the dynamic response of structural components and systems fabricated from advanced composite materials with embedded sensors".

DESCRIPTION: Electro-mechanical impedance method is a novel technique that uses a co-located piezoelectric actuator/sensor to interrogate and measure the variations of mechanical impedance of a structure. By inspecting the differences between the impedance spectrum of a reference baseline of the structure in an undamaged condition and the impedance spectrum of the same structure with damage, incipient anomalies of the structural integrity can be detected. Since the mechanical impedance of a structure is closely related to its material stiffness and integrity of the structural assemblage, the interrogated impedance spectrum can also provide valuable prognostic information regarding the remaining service life of the structure.

Although much research has been conducted to-date to demonstrate the promising utility of the impedance-based health monitoring technique, many fundamental issues related to the practical implementation of this new method have not yet been addressed, such as the software development that will permit rapid measurements/processing and interpretation of the information delivered in the signals, the effects of impedance signal shifting factors on damage metric indices, and the effect of geometric intricacies of the host structure, and the optimal frequency band to interrogate the sensor and to interpret the resulting impedance spectrum. The effects of the location and size of the damage to the impedance spectrum response of the sensor will also be systematically investigated. The primary parameters, such as the relative location between the sensor and the damage, the size and shape of the damage, and the orientation of the damage relative to the sensor, will be identified and their relation to the impedance spectrum response of the sensor will be also be investigated. In addition, the effects of interactions among multiple sensors will also be studied. This “cross-talking” effect between sensors will be investigated for potential use in establishing tomographic information that may be used to pinpoint the location of damage.

Damage modes in advanced composite materials that occur in a typical US Army aircraft (manned and unmanned) include resin cracking, fiber-matrix debonding, delamination, fractured fibers, fiber misalignment, improper cure, voids, inclusions, micro cracks, etc. These different damages are caused during the manufacturing process or developed during service loads. The manufacturing process and service loads are the external stimuli. These degradation can cause the structure to lose stiffness and strength and could have catastrophic effects if not detected.

One damage tolerance approach introduced by the aerospace industry is to establish two quantifiable measures as threshold levels. Two quantifiable measures could be (1) a prescribed impact energy level (100 ft lb) and (2) a visual damage level (0.10 inch indentation).

During the validation phase, an initial test can be conducted on a "path-finder" specimens which is used to verify that the test procedure and instrumentation/equipment are operating correctly.

The loading spectrum input for the sensor network will be based on typical US army aviation system like RAH66 Comanche, UH60 Blackhawk, AH64 Apache, UAVs Shadow and Hunter loads spectrum.

Since the impedance-based method uses a small and non-intrusive piezoelectric sensor patch element, it can be easily installed in new structures or retrofitted to exiting structures. This health monitoring and prognostic technique can also be implemented in an on-line fashion. Furthermore, the effect of interactions among multiple sensors, i.e., the cross-talking effect, could be used to establish tomographic information to pinpoint the location of damage and degradation.

This health monitoring technique can be installed non-intrusively in new structure or retrofitted to an existing structure and can provide a condition-based maintenance program, replaced parts only when needed and not on a time-interval basis. The assurance of structural integrity/reliability of military air and land vehicles and weapon systems will greatly enhance confidence in their safety, reduce the probability of mission failures, and diminish the costs of operations and maintenance. By continuously monitoring the composite structures in question, we will be able to assure their condition of health and integrity and either prolong their life span or prevent catastrophic failure.

PHASE I: Perform a feasibility study on the full potentials of the impedance-based piezoelectric sensor technique for military applications, such as on-board diagnostics/prognostics sensor for Unmanned Aerial Vehicle. Develop a deterministic algorithm for interpreting the sensor signal outputs.

PHASE II: Further define the deterministic algorithm and evaluate the Impedance-Based Structural Health Monitoring and Prognosis Instrumentation, including its associated software/algorithms, models, and diagnostics/prognostics decision tools, for providing integral and continuous inspection in real-time to detect damage at a early stage where repair can be done at a relatively low cost.
Develop a prototype model-based assessment method that incorporates the electro-mechanical interaction between the host structure and the sensor. This prototype model needs to be established for quantifying the sensor signals.

PHASE III: Verification of the structure health monitoring and prognostic technique/system. Explore the applications to other military systems and civilian sectors. Modify the technique, as necessary, to fit other military/commercial applications.

REFERENCES:
1) Chaudhry, Z., Joseph, T., Sun, F. P., and Rogers, C. A., 1995a, ?Local-Area Health Monitoring of Aircraft via Piezoelectric Actuator/Sensor Patches,? SPIE, Vol. 2443, pp. 268-276.
2) Chaudhry, Z., Lalande, F., Ganino, A., and Rogers, C. A., 1995b, ?Monitoring the Integrity of Composite Patch Structural Repair via Piezoelectric Actuators/Sensors,? Proceedings of the AIAA/ASME/ASCE/AHS/ASC 36th SDM Conference, New Orleans, LA, Vol. 4, pp. 2243-2248.
3) Huston, D., Fuhr, P. L., Beliveau, J. G. and Spillman, W. B. ?Structural Member Vibration Measurements Using

a Fiber Optic Sensor,? Journal of Sound and Vibration, Vol. 149, No. 2, 1991, pp. 348-353.
4) Lalande, F., 1996, ?Non-Intrusive Qualitative Health Monitoring of Composite Reinforcement Applied to Norfolk Pier 11,? Project Report, Center for Intelligent Material Systems and Structures, VPI&SU, Blacksburg, VA.

KEYWORDS: electro-mechanical impedance, piezoelectric, stiffness, structure, smart structures, structural dynamics, and structural health monitoring

A03-148 TITLE: Hypersonic Material Technology for Missile Components

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO AMD & PEO TM

OBJECTIVE: The objective of this topic is to develop the Hypersonic Material Technology Design Guide and Database for use in hypersonic missile design. This design guide and database will provide a means of assessing the current state of the art and direct future research in hypersonic materials, analytic methodologies, and aerothermal test facilities for the next generation hypersonic missile systems.

DESCRIPTION: A significant increase in the interest for hypersonic missile systems has developed to reduce reaction time in missile defense as well as identify the future Hypersonic Space Plane technology. The resulting severe environments can induce temperatures in excess of 3000°F on surfaces and leading edges. Much of the current material technology utilized in missile design is limited in temperature capability below what is required for hypersonic flight resulting in the use of external thermal protection systems. These flight conditions range from sea level hypersonic short flight times to high altitude hypersonic flight for long flight times. This topic will provide a rigorous investigation into current and future state of the art material technology and ultimately result in the development of the Hypersonic Material Technology Design Guide and Database providing a significantly valuable and enabling design tool for hypersonic missile programs. The material applications of interest for this topic include external thermal protection systems, composites, nozzles, and leading edges. Specifically addressed will be identification of existing material technologies, survey of other research programs developing new material technology with application to hypersonic missiles, identification of existing analytic design tools, and guidelines to selection of the various available aerothermal facilities. Significant leveraging is possible through the interaction with other Small Business Innovative Research programs being conducted by the Missile Defense Agency, Navy, Air Force, and DARPA addressing the development of new hypersonic material technology and aerothermal facility enhancements. These material technologies have application to DoD as well as the NASA/Air Force/Navy National Aerospace Initiative.

PHASE I: During Phase I, a program plan will be developed for the generation of a Hypersonic Material Technology Design Guide and Database. Phase I will focus on identifying all necessary components of the design guide and database. These components will define the design guide and database to be developed under PHASE II. These necessary components are to address material descriptions and applications, material thermostructural properties, existing and proposed utilization, existing analytic tools and methodologies for designing hypersonic material technology and integration into missile systems, and a complete description of aerothermal test facilities and application guidelines for material technology test and evaluation.

PHASE II: The Phase II effort will be devoted to generating the Hypersonic Material Technology Design Guide and Database. The components defined during Phase I will represent the specific topics incorporated under Phase II. The design guide will be generated in both digital and written versions. The digital version will be platform independent to accommodate a variety of computer operating systems and provide Internet access to other database systems. The software approach will be developed so as to allow continuing upgrades and addition of analytic and experimental data. Additional research will be devoted to identifying promising material technologies having insufficient property data or aerothermal test data. The design guide and database will provide information critical to conducting analysis and design as well as selection of material application and ground test facilities.

PHASE III DUAL-USE APPLICATIONS: This topic has significant potential in dual use for DoD, NASA, and future hypersonic space plane applications. The Air Force, Navy, and NASA are currently devoting efforts in hypersonic material technology for their system requirements. This topic will add the Army application and potentially increase leveraging of the DoD/NASA concurrent efforts. This topic will also allow for significant leveraging opportunities available in various SBIR programs, such as the Missile Defense Agency, addressing in disconnected efforts new hypersonic material technology, aerothermal test facility upgrades, and analytic design methodologies.

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5) Koo, J. H., "Thermal Characteristics Comparison of Two Fire Resistant Materials," Journal of Fire Sciences, Vol. 15, May/June 1997.
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KEYWORDS: Materials, Leading edges, Control Surfaces, Hypersonic, Thermal protection systems, Heatshield materials, Integral heatshield composite airframe, Aerodynamic heating, Aerothermal analysis, Aerothermal test facilities, Composites, Ceramics, Scramjet, Ramjet

A03-149 TITLE: A Throttling Solid Propellant Rocket Motor with Adaptive Thrust Control

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO, Air and Missile Defense

OBJECTIVE: To design, develop, and demonstrate a throttling solid propellant rocket motor that provides total thrust management capability for a tactical missile application through adaptive control techniques and through propellant extinguishment techniques.

DESCRIPTION: Current thrust control techniques for solid propellant rocket motors involve variable area nozzles. A design is sought, but is not limited to variable area nozzles, to provide the capability to throttle thrust a minimum of 15:1, while providing the unique capability of minimizing thrust losses due to non-optimum nozzle expansion conditions. An additional capability is to provide extinguishment of the solid propellant, or near-extinguishment, so that total thrust management is provided. Adaptive control techniques should be explored that interface with the thrust control concept to provide a closed-loop control system capability with the intelligence necessary to provide on-demand thrust to the missile. Traditional control methodologies ignore the important ignition transient phase. Thrust control during the ignition transient phase should be explored to provide total propulsion system control methodology.

PHASE I: Phase I shall encompass a feasibility study of thrust control throttling concept(s) to provide thrust management while minimizing performance losses. Losses due to non-optimum nozzle expansion conditions should be minimized to less than 5%. Propellant extinguishment and near-extinguishment methods should be evaluated. Adaptive control methodologies, to include control of the ignition transient phase, should be explored for optimal control. Simulations as well as performance prediction modeling shall be used in the above evaluations. Any simulations or models should be provide to the Government for independent evaluation of the concepts.

PHASE II: Phase II shall encompass the development and demonstration of a prototype throttling solid propellant rocket motor. Sufficient simulation and testing shall be conducted to evaluate performance losses due to nozzle conditions. The adaptive control methodology, to include control of the motor ignition transient phase, shall be fully evaluated through simulation and testing with hardware. Extinguishment and/or near-extinguishment of the propellant shall be demonstrated through hot fire static testing of the prototype rocket motor. Phase II shall culminate in a final hot fire static test of the throttling rocket motor. Data from the test shall be used to validate the hardware and adaptive control methodology. A prototype shall be delivered to the Government for independent evaluation, to include all software, hardware, and computer equipment necessary to evaluate the rocket motor.

Phase III DUAL USE APPLICATIONS: The technology is of direct use by the National Aeronautics and Space Administration on spacecraft and satellites where thrust management is required. Adaptive control methodologies could be used in the automotive and aircraft industries.

REFERENCES:
1) Susan L. Burroughs, "Status of Army Pintle Technology for Controllable Thrust Propulsion", AIAA-2001-3598, AIAA Joint Propulsion Conference Proceedings, July 2001.
2) M.J. Ostrander, J.L. Bergmans, M.E. Thomas, S.L. Burroughs, "Pintle Motor Challenges for Tactical Missiles", AIAA-2000-3310, AIAA Joint Propulsion Conference Proceedings, July 2000.

KEYWORDS: Throttling, Thrust Management, Solid Propellant, Rocket Motor, Adaptive Control, Propellant Extinguishment

A03-150 TITLE: High Speed X-Band Single Pole 4 Throw Switch

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a high speed X-band switch for controlling antenna selection.

DESCRIPTION: The US Army AMCOM's Hardware-in-the-Loop (HWIL) facilities, and HWIL facilities throughout DOD require the capability, to update target return positions at 60 MHz or faster to support modern MilliMeter Wave (MMW) guided weapon system testing. HWIL testing allows a complete testing of software and guidance hardware prior to test flights, allows for optimization of limited test resources, and allows testing of advanced techniques and wave forms without open air broadcasting of signals. This type of testing has become increasingly valuable in the successful development of new weapon systems. This type of testing will almost certainly be required for the future development of advanced armament for FCS. In past facilities, this had been accomplished using a high speed pin diode switch with rise and fall times less than 200 nanoseconds. This is no longer possible at a switching rate of 60 MHz or more, this rise and fall time causes a significant spurious response at the switching rate. These switching spurs could cause a limitation of the fidelity of the simulation. In order to reduce the switching spur magnitude, a faster rise and fall time is required. A completely new, innovative type of control logic will be required. Research is required to re-look at the problem as this has to be a complete rethinking of how such switches operate.

In addition to supporting the development of advanced armament and ammunition for FCS, future collision avoidance devices in the commercial sector will require similar test capabilities. The development of this high speed switch however, can not be directly supported by private institutions.

This topic solicits innovative solutions in the following technology areas: 1) Rise and fall times of less than 3 nanoseconds; 2) Switch port isolation of 65 db or more; 3) latching logic with a strobe; 4) spurious response of less than 30 dBc.

More generic requirements are listed below:

Frequency of operation 9-11 GHz
Insertion loss < 2.5 dB

RF Connectors - SMA female
VSWR 1.2 :1
Power supply voltages : TBD
RF power maximum +20 dBm
RF power with out damage +27 dBm
Phase matching port to port - +/- 2 deg at 10 GHz
Phase tracking across freq. (port to port) +/- 2 deg
Amplitude tracking across freq (port to port) +/- .2 dB
Power and logic connector - TBD

PHASE I: Proposals should address the following: A mathematical model predicting the spurious response as a function of switching rates. A design concept that will decrease the spurs associated with high speed switching.

PHASE II: Develop a prototype Single Pole Double Throw (sp2t) switch that has predictable spurious response.

PHASE III: Develop a prototype Single Pole Four Throw (sp4t) switch that has acceptable spurious response and meets mechanical configuration.

REFERENCES:
1) Most RF high speed switches available at this time are pin diode switches.
2) There are GaAs technology for switches at lower frequency. These should work at 10 GHz. There is a book available that covers GaAs technology.

BOOK SUMMARY FOR GaAs

Covers the use of MESFET devices in microwave circuits (such as low-noise amplifiers, mixers, oscillators, power amplifiers, switches and multipliers). Includes such topics as: semiconductor theory and transistor performance, CAD considerations, intermodulation, noise figure, signal handling, S-parameter mapping, narrow and broadband techniques, packaging and thermal considerations. Perhaps the most comprehensive text on GaAs FET technology and its practical application.

Microwave Field-Effect Transistors is the third edition of Raymond Pengelly's 1981 book Microwave Field Effect Transistors Theory, Design and Applications. Although the industry has changed over the past 16 years, this book remains a fundamental resource for all engineers involved in the development of solid state microwave devices. This edition includes several updates, and the computer sections have been modernized.

CHAPTER TITLES
Introduction, GaAs Theory - Small Signal, GaAs FET - Theory Power, Requirements and Fabrication of GaAs FETs, The Design of Transistor Amplifiers, FET Mixers, GaAs Fet Oscillators, FET and IC Packaging, Novel FET Circuits, Gallium Arsenide Integrated Circuits, Other III-V Materials and Devices.

3) There is research in using other types of materials instead of GaAs.
4) Photo-conductive Microwave switches.
5) Magazine articles: MICROWAVES & RF MARCH 2000. 93 The design of a higher-order multi-throw switch requires the addition of a series capacitive element for each throw at the junction. In this case, that element is the drain-to-Size : 75.0KB
6) MWRF October 1999 - SiC MESFET Delivers 10-W Power At 2 GHz
<http://www.mwrf.com/Articles/Index.cfm?ArticleID=9613&Extension=html>
This innovative semiconductor technology offers the outstanding thermal conductivity and electron velocity needed for creating high-power, high- ...
7) http://www.mwrf.com/Globals/PlanetEE/Content/16047.pdf
<http://www.mwrf.com/Articles/Index.cfm?ArticleID=16047&Extension=pdf>
CMOS SOS SWITCHES Peregrine Semiconductor’s Ultra-Thin-Silicon (UTSi) Technology enables the real-ization of quality RF switch-es using dielectric isolation between UTSi MOSFETs that are fabricated in CMOS. ...

KEYWORDS: Single Pole Double Throw (sp2t), Single Pole Four Throw (sp4t)

A03-151 TITLE: <u>Diode-Pumped Solid-State Laser (DPSSL) for Airborne Laser Radar</u>

TECHNOLOGY AREAS: Sensors

OBJECTIVE: All U.S. military services are now pursuing various types of laser radar systems for surveillance, detection and acquisition, and/or terminal guidance to targets of interest. This task specifically addresses the laser transmitters that are necessary for laser radar sensors in expendable munitions. The primary U.S. Army application is the NetFires Loitering Attack Munition (LAM), with other potential applications including unmanned aerial vehicles (UAV) and guided submunitions. This task will investigate and develop specific techniques for miniaturizing laser devices for expendable munitions, with the key requirements being a very small physical size; hardening against vibrational, acceleration, and temperature extremes; capability of withstanding long storage times, followed by limited duty cycles of 1-3 minutes, (and in related applications up to 30 minutes); and capability of mass production at low unit costs. This task will address all components of the laser transmitter system: optical bench and resonator, output optics, power supplies, cooling requirements, housing, connectors, etc. The laser device is a high repetition rate, diode-pumped solid-state laser transmitter, using either conventional laser rods, slabs, or fiber materials. For military applications, the laser transmitter might be part of an expendable laser radar or other laser communication system, where only one-time operation might be required. Commercial applications might include remotely emplaced laser transmitters, perhaps part of environmental sensors, that may operate only intermittently, but due to physical space, temperature, or other environmental constraints require unique designs and miniaturized packaging.

This investigation will require detailed experience in solid-state lasers and electro-optical designs, with their associated electronics, power supplies, controls, and cooling functions, all optimized for mass production. Emphasis should be placed on a compact, lightweight, self-contained, and electrically efficient design, ruggedized for high-speed airborne applications over temperature extremes.

DESCRIPTION: This task will concentrate on all key elements of the laser. The laser transmitter may have the following typical characteristics: solid-state, diode-pumped laser operating at 1.06 or 1.5 microns nominal wavelength, pulse repetition rates typically 20-30 KHz, average laser output power 5-10 watts. Individual laser pulses may be on the order of 0.3-1.0 millijoule with pulse widths of 5-20 nanoseconds, for peak powers near 25-100 Kw.

PHASE I: In Phase I, an assessment will be made of the key subsystems and components of typical laser configurations, with an analysis of those areas for which significant gains may be made toward miniaturization, cost reduction, hardening, and mass production. Recommendations for investigating the most promising techniques to meet the desired criteria will be developed. These recommendations will serve as a plan for Phase II hardware construction, demonstration, and testing.

PHASE II: In Phase II, a laser design(s) will be developed, which show most promise in adequate laser output performance along with enhancements toward miniaturization, hardening, capability for mass production, and capability for cost reduction in quantity procurements. After testing of laboratory configurations, the most promising design(s) will be implemented in prototype laser hardware to demonstrate proper laser operation at required duty cycles, with testing at the contractor's facility. The laser hardware will be fully packaged, suitable for delivery to the Army for testing and field experiments. Follow-on activities by the Army are planned for insertion of the laser transmitter configuration into a complete laser radar system for ground and captive flight tests.

PHASE III: The primary military application is a laser transmitter source for use in laser radars. Commercial applications include indoor uses for portable lasers in such diverse areas as medical fields, inspection and monitoring, process control, production flow, etc. Outdoor applications include environmental monitoring, unattended sensors, remote operation of sensors in hazardous environments, etc. In many of these applications a compact, self-contained, high-efficiency laser system is required.

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1) Walter Koechner, Solid-State Laser Engineering (Springer Series in Optical Sciences, v. 1), published by Springer-Verlag, Fifth ed., 1999.
2) Richard Scheps, Introduction to Laser Diode-Pumped Solid State Lasers (Tutorial Texts in Optical Engineering, v. TT53), published by SPIE Press, 2002.
3) Claude Sarno, Georges Moulin, Thermal Management of Highly Integrated Electronic Packages in Avionics Applications, Electronics Cooling, v.7 n.4, p.12-20, Nov. 2001.
4) Stephen J. Matthews, "Light from Crystals, Back to Basics: Diode-Pumped Lasers", Laser Focus World, v.37 n.11, p.115-122, Nov. 2001.
5) Larry Marshall, Diode-Pumped Lasers Begin to Fulfill Promise, Laser Focus World, v.34 n.6, p.63-72, June 1998.
6) Eric J. Lerner, Diode Arrays Boost Efficiency of Solid-State Lasers, Laser Focus World, v.34 n.11, p.97-103, Nov. 1998.
7) DPSS Lasers Move Forward, Lasers & Optronics, p.13-14, Oct. 1998.
8) Valentin Gapontsev, William Krupke, Fiber Lasers Grow in Power, Laser Focus World, v.38 n.8, p.83-87, Aug. 2002.

KEYWORDS: laser, diode-pumped, solid-state laser, fiber laser, laser diodes, laser radar

A03-152 TITLE: <u>A Logistic Regression Model for Single Shot Missile Reliability Prediction</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PATRIOT PMO

OBJECTIVE: Extend missile shelf life by developing a binary logistic regression reliability model.

DESCRIPTION: The Army maintains a Stockpile Reliability Program to assess and predict missile population reliability and readiness. These reliability predictions are used to support missile shelf-life extensions and make decisions concerning missile condition codes. Imprecise estimates can result in tens of millions of dollars unnecessary cost to the Army. Current methodologies rely on standard linear regression statistical techniques using missile age as the primary independent variable. Other statistical techniques exist which might be applicable to reliability analysis of one-shot devices, such as binary logistic regression. However, although logistic regression is often employed in the social sciences, little effort has been made to apply this techniques to reliability assessment. This topic is to explore a binary logistic regression statistical model to predict missile reliability.

PHASE I: Phase I is to perform a feasibility study for applying binary logistic regression to missile stockpile reliability assessment. Potential covariates should be identified and explored in the development of this regression model, including, but not limited to, missile configuration, storage location, manufacturer, environmental history, component testing, and flight testing. Preliminary data should be collected. An assessment of logistic regression versus standard linear regression for missile stockpile reliability should be included in Phase I.

PHASE II: Phase II should finalize selection of covariates, collect additional data, and develop a prototype logistic regression model.

PHASE III: Phase III should develop a final model and validate the model using actual missile stockpile reliability data. Army applications include all missile systems, including legacy and future systems, such as STINGER, PATRIOT, and Common Modular Missile. This model will replace the existing standard regression models used by AMCOM. Commercial applications include reliability assessment of commercial one-shot devices and systems, such as vehicle airbags and other safety-critical one-shot systems.

REFFERENCES:
1) David Hosmer and Stanley Lemeshow, Applied Logistic Regression, Second Edition, John Wiley & Sons, Inc., 2000.

2) Elizabeth King and Thomas Ryan, ?A preliminary investigation of maximum likelihood logistic regression versus exact logistic regression?, The American Statistician, August 2000.
3) John Orme and Cheryl Buehler, ?Introduction to multiple regression for categorical and limited dependent variables?, Social Work Research, March 2001.
4) Robert Oster, ?An examination of statistical software packages for categorical data analysis using exact methods?, The American Statistician, August 2002.
5) Jerry Lawless, ?Statistics in Reliability?, Journal of the American Statistical Association, September 2000.

KEYWORDS: binary logistic regression, reliability, stockpile reliability, statistics, one-shot devices

A03-153 TITLE: Advanced Gel Propellent Fuel

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: THAAD Project Office

OBJECTIVE: Develop an advanced fuel gel that contains more energy per unit volume, atomizes more readily for improved combustion efficiency, and retains the stability of existing fuel gels.

DESCRIPTION: The current baseline fuel for gel propulsion systems is monomethyl hydrazine (MMH) gelled with a polymeric gellant. The objective of this topic is to develop a MMH-based advanced fuel gel that provides higher volumetric specific impulse (r*Isp), incorporates a combustible particulate gellant, and has established spray characteristics. The major tasks are: 1) identify a solid fuel additive that increases the density-impulse by at least 25 lbf*s/in3, and produces a minimum signature exhaust; 2) replace the polymeric gellant with a combustible particulate gellant; 3) formulate the solid-loaded fuel gel to meet the standard centrifuge stability test of 30 minutes at 500g acceleration with less than 3% syneresis; 4) demonstrate that the solid-loaded fuel gel withstands an accelerated aging test of 60°C for 6 months without gas evolution or a change in physical properties, 5) determine how surface tension affects wetting of the gellant and solid fuel additive, rheological properties of the gel at high shear rates, and spray formation; and 6) characterize the combustion with the baseline inhibited red fuming nitric acid gel. Tasks 5 and 6 are the principle objectives of this topic and are expected to receive the most attention. Task 5 should include, but not be limited to, determining how surface tension affects: 1) the amount of syneresis from the centrifuge stability test; 2) the apparent viscosity at 100,000 s-1; and 3) the average spray droplet diameter. Task 6 should include, but not be limited to, the mapping of gravimetric specific impulse (Isp) and volumetric specific impulse as a function of mixture ratio and surface tension. The engine tests will be performed at a constant temperature near ambient.

PHASE I: Identify a minimum of 5 candidate formulations. These should be supported by predictions of gravimetric and volumetric specific impulses determined with a propulsion industry accepted thermochemical code. The procedure needed to study surface tension will be prepared and will include how to determine the surface tension of MMH with the gellant, solid additive, engine injector, and air (the composition of the combustion chamber gases at engine start-up), and how to determine the average spray particle size. A preliminary engine test plan will be prepared that contains the test matrix and analysis procedure. The formulation study will be initiated.

PHASE II: Formulation studies will be completed and a minimum of three formulations with different surface tension properties will be selected for further evaluation. The surface tension study will be performed to determine how this property affects physical properties and spray formation. The engine test plan will be finalized and tests performed to determine the dependence of engine performance on mixture ratio and surface tension (spray droplet size). The engine tests will provide data for at least four mixture ratios using the formulations selected at the end of the formulation task. A final formulation will be selected based on the results from Phase II.

PHASE III DUAL USE APPLICATIONS: Gel bi-propulsion systems can be used by NASA for launch vehicles, spacecraft, and satellites. They are applicable for simple boosters as well as where variable thrust is required. The increased 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 advanced fuel gel formulation can also be for Air Force, Navy and MDA propulsion systems.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: An advanced gel propellant fuel would minimize propellant volume for developing gel propulsion systems, such as a single advanced missile that could replace several single use systems currently deployed. Such a system would greatly reduce logistics and training costs. The precision of the thrust control provided by gel engines increases kill probability and multi-mission flexibility, thereby reducing the number of missiles needed in the arsenal. The savings to the government could exceed 1 billion dollars if a single missile using a gel propulsion system replaces several existing systems.

REFERENCES:
1) George P. Sutton, "Rocked Propulsion Elements: an introduction to the engineering of rockets." 7th Edition, John Wiley & Sons, 2001.

KEYWORDS: fuel gel, particulate gellant, surface tension, rheology, spray formation, accelerated aging, monomethyl hydrazine, engine testing

A03-154 TITLE: Advanced Gel Bipropulsion Tank System

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: THAAD Project Offic

OBJECTIVE: Develop an advanced gel bipropulsion tank system (ATS) that contains mechanically linked pistons to guarantee a constant volumetric Oxidizer-to-Fuel (O/F) ratio.

DESCRIPTION: The key elements of this program are to design, fabricate, and demonstrate an innovative tank design that maximizes volumetric efficiency, minimizes volume, weight, and cost, and mechanically links the two pistons to assure that the tank delivers the oxidizer and fuel gels at a constant ratio at temperatures ranging from -40° to +63° C.

PHASE I: Develop three innovative preliminary gel bipropulsion tank system designs for the Army baseline monomethyl hydrazine (MMH) fuel and inhibited red fuming nitric acid (IRFNA) gels. The systems are to be 7 inches in diameter, 15 inches long, and have an O/F mixture ratio of 2.5. One of the designs will be using a central solid gas generator with the mechanically linked fuel and oxidizer pistons moving in opposite directions. The second design will have tandem tanks with a forward placed solid gas generator that pushes mechanically linked pistons toward the engine. The third design will be have coaxial tanks with a forward placed solid gas generator that pushes mechanically linked pistons toward the rear. All three designs will feature a pressure relief system for both the oxidizer and fuel gels to assure passing Insensitive Munitions (IM) requirements.

PHASE II: The government will select which design is most attractive for tactical missile systems at the beginning of Phase II. The final design of the ATS will be prepared optimizing all parameters and considering material compatibility with the propellants. A prototype ATS system will be fabricated and tested at AMCOM to demonstrate its performance. This prototype will substitute cold gas for the solid gas generator; however, the volume and interfaces to the rest of the ATS will be identical.

PHASE III: With funding from a specific missile program or development office, six flight-weight ATS systems will be fabricated for bullet and fragment impact, slow and fast cook-off, and sympathetic detonation IM testing and a final proof-of-principle hot-fire test using a solid gas generator and a vortex engine furnished by the government.

PHASE III DUAL-USE APPLICATIONS: Gel bipropulsion systems can be used by NASA on launch vehicles, spacecraft, and satellites. They are applicable for simple boosters as well as where variable thrust is required. The increased safety of gel engines can reduce the number of engines on spacecraft. For instance, a single engine could be used for changing from low to high earth orbits as well as precision positioning of the satellite for operational purposes, such as detecting leaking dams or mapping crop infestations. The precision of the ATS in delivering gels to thrusters at a constant volumetric O/F ratio will be very attractive to space applications, although a different pressurization system would probably be desired. ATS tanks would also be applicable to Air Force, Navy, and MDA systems because they, also, have size and weight constraints and IM requirements.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: An ATS would minimize the cost and schedule for the development of a single advanced missile that could replace several single use systems currently deployed. Such a system would greatly reduce logistics and training costs. The precision of the thrust control provided by gel engines increases kill probability and multi-mission flexibility, thereby reducing the number of missiles needed in the arsenal. The savings to the government could exceed 1 billion dollars if a single missile using a gel propulsion system replaces several existing systems. If multiple systems are to be retained, a common set of engine hardware could be integrated into TOW, Javelin, Hellfire, Common Missile, NLOS-LS, and possibly Stinger type missile systems.

REFERENCES:
1) George P. Sutton, "Rocket Propulsion Elements: an introduction to the engineering of rockets," 7th Edition, John Wiley & Sons, 2001.

KEYWORDS: Bipropellant Tanks, Gelled Propellants, Unique Design, Constant O/F Delivery Tanks

A03-155 TITLE: Development of Medic Blood Pack

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Development of medic blood pack – mobile blood storage containerfor blood product transport and use forward of the Forward Surgical Team

DESCRIPTION: Recent military experiences in Afghanistan and the Middle East have demonstrated a need for lightweight storage containers for carrying blood products, such as packed red blood cells, far forward of the Forward Surgical Team (FST). Current doctrine governing rapid deployment and intense conflict include an expectation of delayed troop evacuation times of at least 24-48 hrs. While the proper use of body armor by Special Operations troops has resulted in a higher proportion of extremity wounds, soldiers continue to die of exsanguination from wounds received at plate junctions and other unprotected areas. Bleeding from such wounds (e.g., transit of the hip girdle by a high velocity round) often cannot be fully controlled at the point of injury, but life-saving survival times likely can be gained by availability of a vascular volume expanding oxygen carrier such as packed red blood cells. The wounded soldier can then make it to evacuation to the FST, where he/she can subsequently be stabilized. In this scenario there is a requirement for a light, thermally efficient container that can maintain blood product units within required temperature ranges (1 to 10 Deg C for packed red blood cells) for a minimum of 48 hrs, 72 hrs for a proper margin of safety, under extreme environmental conditions (-20 to +40 Deg C). Medics would carry 5 to 6 units of such a blood product. Size and weight limitations therefore dictate that the container must be only slightly larger than the aggregate blood product units and be capable of maintaining unit temperatures within the required range without doubling the weight load or requiring ice. Recent advances in thermal barrier material technologies open up the possibility that a container (hard shell, insulated, and light-weight) can be constructed that would allow medics to carry 5 to 6 units of packed red blood cells far forward in the absence of ice, an external power source, or batteries. Advances in thermal measuring technologies hold out the additional possibility that a temperature-recording device could be incorporated into the design.

PHASE I: Identify lightweight materials that will be capable of maintaining 5 to 6 units (up to 500 ml each) of packed red blood cells within the required temperature range (1 to 10 Deg C) for 48 to 72 hrs without ice. Identify an appropriate outside shell material for such an insulated container. Design and construct a container with these materials that will no more than double the weight of the aggregate units and demonstrate temperature-maintaining efficiency under extreme external conditions (-20 to +40 Deg C). Size must be such that the container can be adapted to attach to a standard military-issue field pack or easily carried with a shoulder or waste strap. Ideally, the unit will integrate with the army's new MOLLE system, a description of which can be found at SBCCOM ONLINE (see www.natick.army.mil/warrior/01/sepoct/packitup.htm). Identify a temperature-monitoring device that can be integrated into the blood pack. MRMC assets and protocols are already in place that can support evaluation of red cell unit storage in this phase of the project.

PHASE II: Demonstrate efficacy of the storage container in extending non-refrigerated red blood cell storage time by maintaining unit temperatures within the prescribed range under extreme conditions. Perform or participate in clinical laboratory testing of units stored under field-simulated conditions (validation of box and contents). Incorporate temperature sensing/recording device and demonstrate workability and durability. Since FDA requirements only stipulate that red blood cell units have to be maintained within the stated temperature range it is not anticipated that clinical trials will be necessary to field this device.

PHASE III DUAL USE APPLICATIONS: Produce and support use of such a storage container during its introduction into clinical use. Addresses a market for provision of current and future (e.g., hemoglobin-based red cell substitutes) blood products in rural and disaster care situations where refrigeration is not available.

REFERENCES:
1) TM 8-227-11 (Operational Procedures for the Armed Services Program Elements).
2) TM 8-227-12 (Armed Services Blood Program Joint Blood Program Handbook).

KEYWORDS: blood, red blood cells, blood products, storage container, mobile blood storage container, blood pack storage

A03-156 TITLE: Skeletal Muscle Water Content Measurement Sensor/Tool

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: DSA,MRMC

RATIONALE: Body water balance (hydration status) depends on the net difference between water gain and water loss. Water gain occurs from consumption (fluids, ingested food) and production (metabolic water), while water losses occur from respiratory, skin, renal and gastrointestinal tract losses. Total body water (TBW) is the “Gold Standard” to determine hydration status, and is accurately determined by dilution of a variety of indicators. Repeated measurements are required to access TBW changes. The technical requirements and cost for repeated measurements with dilution methods make them impractical for routine assessment of TBW changes. Bioelectric impedance analysis (BIA) has been used, but does not have the resolution to measure hydration changes and is confounded by many factors normally encountered by soldiers. Plasma osmolaltiy provides the best hydration marker for hyperosmotic-hypovolemic dehydration, but is not an acceptable marker for iso-osmotic-hypovolemia dehydration. Other hydration markers of plasma and urine are not quantitative and can be easily confounded. Muscle provides the largest body reservoir for water and it will decrease with dehydration. The developed sensor should be able to track reductions in muscle water content (wet/dry weight ratio) and reductions in TBW (dilution, body weight & other appropriate indices).

OBJECTIVE: Develop a sensor / tool to measure body hydration status (via measuring muscle water content) in soldiers during deployment and training. Skeletal muscle water content will decrease when soldiers dehydrate and this measurement will serve as an important component of a body hydration monitoring system. Currently there is no valid quantitative measure of body hydration status for field use (rapid, technically simple & not easily confounded).

Soldiers will commonly dehydrate (by 2% to 5% of body weight) due to high rates of water loss from environmental exposure and performing stressful physical work. Dehydration by modest amounts (2% of body weight) will decrease cognitive and physical work capabilities (even in temperate environments), and larger water deficits can have devastating effects performance and soldier health. Likewise, over-hydration can cause serious health problems (hyponatremia) and many of its symptoms mimic dehydration. The goal of this topic is to develop a tool to measure skeletal muscle water content changes in soldiers during field operations. Soldiers will wear the muscle water sensor (and another sensor) to provide a body hydration monitoring system. Such a tool will have civilian medical use to assess hydration status of various patient populations. The employed technology must be safe and eventually be lightweight and compact with low-power requirements.

DESCRIPTION: The envisioned device would employ a technology that is non-invasive or minimally invasive and can measure muscle water content. System requirements include: (1) accuracy of 2% within a range from 2% to 40% reductions in muscle water, (2) not be confounded by plasma and skeletal muscle electrolyte disturbances; (3) not be confounded by skeletal muscle contractions; (4) not interfere with physiologic function, and (5) user friendly technology with potential to be used in field operations.

PHASE I: The contractor will demonstrate proof-of-concept of the approach to measure skeletal muscle water content and potential to discriminate small (2%) reductions in muscle water. This will be supported by documentation of basis for approach, prototype system specifications and data regarding scientific validity.

PHASE II: Contractor will build 5 working prototypes and supporting hardware/software interfaces for evaluations in laboratory in animal and human models. This will be supported by overall system design document and hardware / software prototype. Animal or human studies will be required to obtain appropriate Department of Army, Institutional Review Board approvals, this may take 6-9 months.

PHASE III: This sensor / tool will be integrated with at least one other sensor to develop a commercial body hydration monitor system. The analytic instrument will be extensively tested in laboratory / field studies to demonstrate a sensitive, specific and reliable system for military application. This instrument will be used to manage deployed soldier hydration status to maximize performance and reduce risk of environmental injuries. Such a tool will have civilian medical use to assess hydration status of various institutionalized patient, athlete and worker populations.

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Body Fluid Balance in Exercise and Sport. E.R. Buskirk and S.M. Puhl, Eds., Boca Raton, FL: CRC Press, 1996.

Mack, G. W. and E.R. Nadel. Body Fluid Balance during Heat Stress in Humans. In: Handbook of Physiology, Section 4: Environmental Physiology. C.M. Blatteis and M.J. Fregley, Eds., New York: Oxford University Press for the American Physiological Society, Chapter 10, 187-214, 1996.

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KEYWORDS: dehydration, body water, hydration, hypohydration, skeletal muscle water, water balance

A03-157 TITLE: Generic Flavivirus-Based Vaccine Platform for Biological Threat Agents

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: To develop a generic vaccine platform based on defective flavivirus-like particles(FLP's) that can be used to deliver protective antigens of heterologous pathogens.

DESCRIPTION: Live virus vaccines have been the most successful strategy in producing immunity to viral diseases. Among the flaviviruses, for example yellow fever, dengue, Japanese encephalitis, natural infection induces long-term, probably life-long immunity. The live-attenuated 17D yellow fever vaccine have been given to millions with excellent safety record and induces high protection efficacy (>95%) through a single dose vaccination. The disadvantages of live-virus vaccines are its high reactogenicity and potential risk of reversion to virulent wild-type virus.

Defective flavivirus-like particles containing almost all of its 10 coding genes including structural and non-structural loci, may offer the advantages of strong immunogenicity and safety feature of not reverting to wild-type virus. Results from the work of Kunjin virus suggest that development of a noninfectious vaccine delivery system based on encapsidation of a noncytopathic flavivirus replicon expressing heterologous genes is feasible. (1) Sub-genomic virus-like particles of dengue viruse has been constructed. (2) Recently subgenomic replicons of another flavivirus, West Nile, was shown to be capbale of delivering heterologous protein expression in hamster kidney cells. (3) Unlike naked DNA vaccines or adenovirus-based vectors flaviviruses do not cause persistent infections and do not have any oncogenic potential. Such flavivirus FLP's may be useful as vectors to deliver protective antigens from other pathogens.

PHASE I: This phase will be to determine feasibility. The goals will be: a. To develop cell lines that can stably express subgenomic viral construct containing all non-structural dengue or yellow fever 17D viral coding regions (without protein E region); b. To develop a rescue (or helper) virus vector containing the dengue or yellow fever virus structural gene, protein E that will produce defective FLP's. by infecting the transfectant cell line harboring dengue or Yellow fever non-structural sequences; c. To develop rescue virus vector containing the dengue protein E structural gene and other heterologous genes of interest that can be used to produce defective FLP's expressing the other antigens of interest. The lab-grade yield of FLP's will need to be at least 10exp6 FLP's/ml.

PHASE II: This phase will be to develop: a. process of scale up production of FLP's (pre-GMP) of at least 10exp6 FLP's/ml; b. process of concentration of FLP's should the yield be low.

PHASE III: Pre-clinical safety and animal testing and submission of IND. Manufacture pilot lot of test article under Good Manufacturing Conditions for human clinical trials (Technology Readiness Level 5). The development of high titers FLP's preparation can be used as a potential vaccine candidate to provide efficient protection for US military personnels that are deployed to Flavivirus endemic areas. The future plan after Phase III for the FLP's product will be safety and immunogenicity testing of the dengue VLP to be co-sponsored by commercial company and U.S. Army (Technology Readiness Level 6). The success of FLP's commercialization from this topic will provide an efficient means of developing new vaccine candidates against the emerging militarilly relevalent infectious pathogens.

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2) Pang X., Zhang M., Dayton A. I. Development of dengue virus replicons expressing HIV-1 gp120 and other heterologous genes: a potential future tool for dual vaccination against dengue virus and HIV. BMC Microbiol 2001;1(1):28.
3) Shi P-Y, Tilgner M. and Lo M. K. Construction and characterization of subgenomic replicons of New York strain of West Nile Virus. Virology 2002;296:219-233.

KEYWORDS: pre-GMP, feasibility

A03-158 TITLE: Enhanced Detection and High-Throughput Screening of Proteomic Signatures/biomarkers in Neoplastic Tissue

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: To design and implement a proteomics-based assay system that will incorporate sensitive quantitative detection of biomarkers with high-throughput capabilities.

DESCRIPTION: The advent of functional genomics has provided new avenues for the identification of genes that initiate and support tumor growth. This new technology coupled with analysis of the proteome can lead to new and improved methods of diagnosis as well as therapy that is tailored to a tumor's particular genomic and proteomic profile. Microarray analysis offers a sensitive technique to measure levels of gene transcription allowing one to identify differences in m-RNA production between normal and neoplastic tissue. While microarrays provide valuable information in this regard, gene products regulated at the level of translation and/or post-translational modification are missing from this data profile. Analyses of the proteome, especially the enzymatic proteome, which measure alterations in activity would add additional important information to this picture. The field of proteomics is in its infancy and current technologies for analysis are limited to measuring abundance without considering protein activity. Therefore, it is of great importance to develop this technology further with both of these objectives in mind. Information from both microarray analysis and proteomic analysis will lead to early and accurate diagnosis of cancer as well as increase our ability to adapt to a tumor's changing phenotype as a particular therapy progresses. Additionally, this technology will be very useful in generating infectious disease profiles and profiles arising out of exposure to agents commonly used in bio- and chemical warfare, all of which have high military relevance. The overall goal of this solicitation is to develop a high-throughput diagnostic tool using protein activity profiles to identify specific disease states such as cancer.

PHASE I: Propose a family of proteins to focus efforts on and design a strategy for synthesis of a probe for detection and measurement of specific protein activity that is associated with breast, ovarian, prostate, and/or lung cancer.

PHASE II: Initiate probe synthesis and characterization in a suitable assay system. Begin analyses of proteomes derived from normal and pathological tissue samples. The probe should be able to successfully distinguish between normal and cancerous/diseased tissue using well characterized controls where possible. Proteomic profiles should correlate with clinical and pathological findings.

PHASE III: This phase would focus on design of high-throughput platforms for the activity assay with the goal to develop a rapid diagnostic tool that can analyze multiple tissue samples accurately. This tool will be highly applicable to military relevant topics including force protection. Early detection of cancers and/or infectious diseases is needed to best care for military personnel and DOD beneficiaries, and to reduce the health care costs incurred in treating and caring for these individuals. Direct application of this technology to military settings is for rapid and accurate detection of exposure to infectious diseases and biological and chemical agents in the environment.

Infectious diseases outbreaks, either through terrorism or natural worldwide outbreaks, must be detected and tracked in order to deal with managing the initial response, targeting resources, evaluating effectiveness, and managing the ongoing response. A proteomic profile assay system will enhance the ability to detect specific diseases and also enhance the time required to identify outbreak.

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KEYWORDS: proteomic, neoplastic

A03-159 TITLE: Personal Area Network for Warfighter Physiological Status Monitoring (WPSM)

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: dsa,mrmc

OBJECTIVE: Develop and demonstrate a wearable personal area network (PAN) to support routine, continuous ambulatory physiological status monitoring of physically active warfighters.

DESCRIPTION: Physiological monitoring of soldiers during training and combat operations is needed to reduce the likelihood of casualties and to improve remote casualty management. To achieve this goal, a reliable personal area network (PAN) (~2 meter range; minimum 9600 baud) is needed to interconnect intelligent sensors scattered about the body (chest, wrist, boot, head, canteen) and one or more data fusion points where physiological state classification can occur. The challenge is to develop a low-power, compact, lightweight PAN that has a minimal electromagnetic signature, and can function in a changeable, constrained, and harsh environment. The system must be easy to don and doff, and accommodate variations in physique, clothing and body-worn equipment, and sensor placement. The number and type of networked sensors will vary with mission. Data streams may be unsynchronized, noisy, and have missing data, and sensors may fail. The PAN must tolerate extremes of temperature, vibration, and immersion. This degree of adaptability suggests a wired/wireless or wireless design.

We seek a novel PAN design that can: (a) interface in a plug-and-play fashion with at least four sensors or sensor-node channels, (b) data transfer and the control of a variety of physiological sensors such as electrocardiogram (ECG), respiration rate, and skin temperature, each with distinctly different data rates and information content, (c) correlate and time synchronize multiple heterogeneous signals and events in time, (d) reconfigure with changes in the sensor array, including adapting to non-responsive and faulty sensors without undue perturbation to available bandwidth and network latency, (e) provide reliable, predictable, low-latency delivery of time series data to a central processor (a key to later processing of the data collected and delivered via the PAN), and (f) can accommodate an unlimited number of PAN users given a maximum spatial density (proximity) of one system per square meter. Comparing and contrasting chosen physical and link layer (software protocol) approaches with evolving industry standards for short-range low-power systems such as IEEE 802.15 (http://grouper.ieee.org/groups/802/15) is desirable.

PHASE I: Define an overall PAN architecture concept, identify planned use of commercial as well as custom elements, and provide detailed performance predictions for the primary performance metrics which are achievable bandwidth, concurrent channels, energy use, and susceptibility to standoff detection and jamming. Phase I may also include risk reduction efforts such as development and demonstration of a single channel solution using commercial available parts and measurement of primary performance metrics.

PHASE II: Develop at least 10 prototype PAN systems suitable for field trials and performance measurement. The emphasis will be on the sensor interface and data collection and collation elements of the PAN, with an interface to a commercial body-worn computer. The Phase II effort will include field trials of the PAN under various working and training conditions to determine the reliability, detectability, jam-ability, energy utilization, bit error rate test performance, and tolerance to the failure of individual sensors. The result of the Phase II effort will be a comprehensive characterization of PAN performance, and a plan for ruggedization and packaging of the PAN elements to support operational deployment.

PHASE III DUAL USE APPLICATIONS: The offeror should aggressively pursue civilian PAN applications. The advancements in telemedicine technology and Web-based monitoring of home health patients drive needs to remotely and automatically evaluate the clinical condition of patients. These sensing and data collection requirements are typically a subset of the capabilities desired for warfighter physiological status monitoring. A robust military PAN technology would also be useful in real-time monitoring of health status of firefighters and emergency personnel working in harsh environments.

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KEYWORDS: Warfighter Physiologic Status Monitor, exercise, home health care, ambulatory monitoring, wearable sensors

A03-160 TITLE: Biomonitors for Real-Time Air Toxicity Monitoring

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: The objective is to develop and integrate advanced biomonitoring technology into a field-deployable platform to provide continuous, real-time monitoring for developing toxic conditions in air. The platform will identify potential health effects on deployed forces resulting from exposures to a wide array of airborne toxic chemicals.

DESCRIPTION: The U.S. Army Center for Environmental Health Research (USACEHR), in conducting research in the field of deployment toxicology, seeks new methods for real-time assessment of continuously monitored biological endpoints to define airborne toxicity. Biological endpoints are considered to include responses from living cells, tissues, or whole organisms. Although many chemical or biochemical sensors are being developed to detect exposure to individual toxic materials, this effort focuses on using real-time biological responses to identify a broad range of toxic hazards that may be due to unsuspected materials or the joint action of chemical mixtures. Technologies are sought for incorporation into a sensor platform deployed in the environment to provide continuous, real-time monitoring information. We are seeking innovative and creative research approaches to address the air toxicity monitoring requirements described below. It is anticipated that more than one biomonitoring approach may be required to achieve these goals:
1. Use biomonitoring technology, including cell- or tissue-based biomonitors or multicellular organism biomonitors, to provide a sensitive and rapid response to a broad range of airborne toxicants (with varying modes of toxic action).
2. Minimize interference caused by variations in environmental parameters such as temperature, airborne particulates, humidity, etc., while continuously monitoring representative air samples.
3. Minimize sample preparation requirements while maintaining air sample integrity.
4. Ensure that living biomonitor components can survive transport and can be stored for at least 30 days prior to use.
5. Provide for continuous, real-time data acquisition and analyses.
6. Integrate functions in a field-deployable platform.

PHASE I: Conduct research to demonstrate the efficacy of one or more individual biomonitors (incorporating responses from living cells, tissues, or whole organisms) for continuous, real-time toxicity detection. The biomonitor(s) will be original or will represent significant extensions, applications, or improvements over published methods. Experimentation must show that the biomonitor(s) exhibit the above characteristics. Proof of concept will be accomplished during a continuous, two-week monitoring period by demonstrating biomonitor response within 30 minutes to at least one toxic chemical of relevance to the military with minimal "false alarms" (responses in the absence of toxic chemicals).

PHASE II: Expand Phase I research to demonstrate the biomonitor=s capability to accurately and continuously monitor developing toxic conditions in real time with minimal interference from variations in environmental conditions. Integrate the biomonitor(s) into a field-deployable platform. Include specific sensors for chemicals or environmental parameters, as required, to augment the biomonitor(s). Provide real-time, continuous data from the platform in a format suitable for real-time off-platform transmission and remote analysis. Evaluate the sensitivity and response characteristics of the biomonitor(s) through laboratory tests with various classes of chemicals including, but not limited to, pesticides, organic solvents, and military-unique substances. Provide a field test of the system that demonstrates operation under ambient air conditions and shows that biological components meet transportation and storage requirements.

PHASE III DUAL-USE APPLICATION: Integrate the field-deployable platform with other similar platforms, creating a network to provide early warning of developing toxic conditions in air and potential hazards to troops. A variety of field applications are possible, including assessment of environmental hazards to troops pre-, during, and post-deployment. Field tests will apply platform/network under variable environmental conditions. The new platforms will increase the reliability and usefulness of current biomonitoring technology by identifying potential toxic chemical hazards to troops. Also, the platforms may be used to monitor and assess the environmental impacts of military site activities and the compliance of such activities with regulatory requirements. Given current on-going concerns regarding accidental or intentional release of air toxics, this technology will have broad application for both state and local governments. USACEHR would consider providing non-SBIR funding after successful completion of Phase II.

OPERATING AND SUPPORT COST REDUCTION (OSCR): Current air monitoring approaches cannot detect a full range of developing toxic conditions as quickly as needed for decision-making under field conditions associated with military operations. 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 chemical detection systems by providing real-time indications of developing toxic hazards due to unsuspected materials or chemical mixtures, thus providing an important capability that is not presently available.

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KEYWORDS: Air Toxicity Monitoring, Toxic Industrial Chemicals, Biomonitor, Real-time Monitoring, Biomonitoring Platform

A03-161 TITLE: <u>Integrated Architecture for Functional Genomic Measurements</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: The overall goal of this SBIR topic is to support efforts in the Objective Force Technology Area:

Biomedical. We seek to capitalize upon recent advances in enabling technologies in systems science and functional genomics.

DESCRIPTION: Specifically, we seek the development of an innovative, fully-functional, locally-controlled, web-enabled product for integrated analysis of De Novo and Affymetrix datasets. Innovative enhancements of informatic tools for microarray technology supports DoD's Defense Technology Area Plan in Infectious Diseases of Military Importance, more specifically, STOs III.ME.1996.01 Multi-Stage, Multi-Antigen Plasmodium falciparum Malarial Vaccine; III.ME.1996.02 Drug to Treat Multi-Drug Resistant and Severe and Complicated Malaria; III.ME.2000 a Multi-Antigen Multi-Stage Plasmodium vivax Malaria Vaccine; WRAIR-1D-03 Antimalarial Drug Discovery .

BACKGROUND: A critical component of the genomics revolution is the capacity to transform enormous amounts of biological information into a relevant format that readily leads to rapid information-based approaches to biological problems. Advanced integrated analysis methods for modeling, conceptualization and inference of underlying functional relationships within the large-scale datasets are critical if we are to recognize the full potential of the genomics revolution. Currently, functional genomic technologies have outpaced the scientific community's ability to extract biologically meaningful information. Development of a robust, innovative, flexible web-enabled system to determine causal relationships among genes and proteins – who is regulating whom and how - is imperative as no commercial product currently exists.

Specifically, we seek development of an innovative, highly flexible relational product and interface package that will utilize recent advances in areas such as systems science, self-organizing processes, bioinformatic methods, and/or adaptive cooperative computing to develop an integrated architecture for higher level analysis of microarray data sets from both De Novo spotted and Affymetrix technologies while remaining compatible with existing formats and technologies. We seek modeling, simulation and/or analysis tools that will aid in overcoming present difficulties in establishing/identifying core regulatory biological networks/interactions among sets of co-expressed genes within these data sets. Capacity to export output to cross-query community databases (e.g. KEGG, PathDB, TRANSFAC, WIT, SPAD) such that biological significance/relevance can be more easily and fully realized is imperative. The product design must be sufficiently flexible to interface and/or recognize output of existing imaging and analysis packages to include, but certainly is not limited to, Spot, GenePixPro, ImaGene, Partek Pro, Expressionist, etc. This product can be modular, a stand-alone program, add-in for a web browser, or simply integrated with a web browser. The product must serve multiple users at 5 sites, with at least 10 persons accessing simultaneously, yet include provision for scalability to 250 persons with up to 25 simultaneous logins. If interested in responding, applicants are encouraged to contact topic author.

PHASE I: Development of a proof-of-concept proposal that will be completed in early Phase II.

PHASE II: Develop proof-of-concept beta version of product with at least 60% of desired features. Demonstration of the beta version of the prototype with at least 60% desired features will result in the termination of Phase II.

PHASE III Dual Use Applications: The development of a platform for robust analysis of the underlying functional relationships implicit in microarray datasets for DOD drug development/discovery and vaccinology programs would be expected to be readily exploited by researchers in other disciplines. A platform that allows researchers to model and conceptualize data to establish/identify core regulatory biological interactions/functions among sets of co-expressed genes would be expected to advance efforts in vaccine discovery, drug development and discovery, toxicology, and diagnosis and monitoring of infectious diseases of military and civilian import (HIV-1, malaria, pathogenic bacteria, viruses, and biothreat agents).

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KEYWORDS: microarrays, proteomics, systems biology, adaptive computing, biological systems theory

A03-162 TITLE: Haptics-Optional Surgical Training System (HOSTS)

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: To develop and demonstrate a computer based Haptics-Optional Surgical Training System (HOSTS) so surgeons can obtain and maintain proficiency in open surgical procedures. 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 both for military and civilian health care providers.

DESCRIPTION: Over the past three 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) and, as one of several funding sources, 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 could improve treatment and reduce surgical errors at fixed military facilities, civilian facilities, medical educational training institutions, and forward deployed locations. 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, and open architecture strategies.

Much discussion and research has focused on the level of visual and tactile realism necessary to effectively transfer skills learned via simulation to actual practice. While tactile 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.

While technology is moving TIVR toward reality, we seek creative and innovative solutions to surgical training that are not as reliant on high fidelity haptics feedback. Many surgeons use robotic devices to assist surgery, but some provide little or no tactile feedback. Yet the image visualization is superior, so many surgeons compensate for the lack of "feel". If true when using a robotics device during an actual procedure, perhaps this is 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.

This open-ended concept requires creative, innovative development so a trainee can learn and practice open-handed surgery procedures on a system that simulates its look and feel. Progress is evident in 3D visualization with or without computer screens. Progress in sensored gloves 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 see and feel a simulated environment.

PHASE I: Develop a concept plan for a Haptics-Optional Surgical Training System (HOSTS). The concept should be broad enough so open-handed surgery procedures can be "practiced":

a. With or without the presence of tactile feedback,
b. Without human, animal, or cadaver tissue,
c. With or without Head Mounted Display units that, if present, are equal or lighter weight and equally or less intrusive than those used during the actual procedure,
d. Based on embedded metrics for comparison of outcomes,
e. With realistic "look and feel" of tissue deformation in response to manipulation of tissue,
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 HOSTS with which a user can simulate the performance of an open surgery of simple to moderate complexity.

PHASE III DUAL USE COMMERCIALIZATION: The HOSTS is desired for application to military and civilian medical training and has the potential to become the foundation for surgical training in the future.

REFERENCES:
1) Discussions at the Advanced Technologies Applied to Combat Casualty Care (ATACCC) Conference, 13 Sep 02, Medical Modeling & Simulation presentation and strategy sessions.
2) Discussions after the Washington Computer Assisted Surgical Society, 17 Sep 02.

KEYWORDS: medical modeling and simulation, surgical training, virtual reality, haptics gloves, force feedback, visualization, 3D graphics, sensors, head mounted display

A03-163 TITLE: Re-Usable Intraosseous Infusion Device

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA,MRMC

OBJECTIVE: To develop a lightweight, portable, rugged, yet re-usable intraosseous infusion device, that can be used by medics in the field under extreme environmental conditions, for infusion of fluids and drugs via the bone marrow. Although infusion into a specific site is not specified, based on military need, the sternum may be the preferred site.

DESCRIPTION: Austere far-forward battlefield environments present numerous obstacles in providing adequate medical care to the injured soldier. In addition to logistic constraints that limit the volume of isotonic crystalloid fluids available to resuscitate the injured soldier, hypotension, environmental and tactical conditions, and/or the presence of mass casualties can combine to lead to excessive delays in obtaining vascular access (1). Intraosseous infusion has been shown to be a rapid, reliable method of achieving vascular access under emergency conditions in children. However, only recently has the concept of intraosseous infusions in adult medical emergencies been revived (1-4). Current intraosseous devices are single use and bulky enough to limit the number of devices that can be carried in the field. Development of a portable device with a reusable handle and disposable intraosseous needles could enable the medic to treat more patients under various combat conditions.

PHASE I: This phase should result in a proof of concept workable device, or at the minimum, specifications and mockups of a potentially workable device. The device could conceivably have a lightweight, portable (battery-operated), rugged handle and driver to which are fit sterile, disposable intraosseous needles suitable for infusions into the bone marrow. Because of the incidence of extremity trauma in recent military conflicts (5), the sternum may be the preferred site of choice for intraosseous infusions. Consequently, the intraosseous needle developed must minimize the risk of injury to underlying vital organs and structures.

PHASE II: This phase should result in a device that could be tested under various experimental conditions. This phase should also result in a ruggedized device that can be used under austere far-forward battlefield conditions.

This device should be small, durable and if applicable, have sufficient battery power under extremes of temperature and moisture conditions.  The laboratory at the US Army Institute of Surgical Research has experimental models of severe shock that potentially could be used to test the device for infusion of drugs and fluids, should a company be interested in such a collaboration.

PHASE III COMMERCIALIZATION:  This instrument would have immediate battlefield application, as well as civilian pre-hospital application, where it could be used by paramedics in the field or on ambulances in both adults and children, under conditions where obtaining vascular access is delayed or conventional catheterization fails.

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KEYWORDS: Severe hypotension, Resuscitation, Intraosseous, Infusion sites, Vascular access

A03-164 TITLE: Diagnostic Microarray Test Based on Comparative Studies of Gene Expression in Humans with Common Inflammatory and Infectious Diseases

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: DSA, MRMC

DESCRIPTION:The elucidation of the genetic events underlying the initiation and progression of human diseases is a very critical step in designing better tools for diagnosis and treatment and the advent of high-density microarray technology has opened up a new way of studying the disease process. High-throughput DNA and tissue microarray techniques promise to revolutionize the discovery and validation of novel molecular markers.

Detection of exposure to biological threat agents currently uses culture methods, immunoassay and gene amplification and these methods constantly are being perfected for greater sensitivity
However, recent events have demonstrated that assessing exposure to a biological threat agent well in advance of onset of illness or at various stages post-exposure would be an important capability to have among the diagnostic options.

Patterns of host cell transcription may prove to be useful for diagnosing infection at a very early stage, sometimes within 1 to a few hours post-exposure.  The ability of diagnostic assays to identify infected individuals during the prodromal period is essential for successful treatment or intervention following exposure and infection with many disease-causing agents.  The identification of early markers of infection using gene profiles by microarray technology offers great promise for revolutionizing disease diagnosis.

cDNA microarray technology is a very sensitive method that allows one to analyze thousands of genes simultaneously. On a glass slide thousands of gene fragments are spotted by a robot, RNA samples are then labeled with fluorescent dyes and hybridized to these spots and measured for their level of expression by the intensity of the signal. Various software packages are utilized to generate the ultimate gene list that is significantly altered upon exposure to the test agent. The ultimate goal of this research effort is to derive a series of gene expression responses to biological threat agents to be used as diagnostic markers for exposure as well as to analyze the information to design stage-specific therapeutic regimens.

We at Division of Pathology, WRAIR, have been using various molecular techniques to detect early gene responses specific to each biological warfare agent (Das et. al, 1998; Ionin et. al, 1999). The goal was to determine a pattern of gene expression changes in response to each BW agent and to use that pattern to identify the course of impending illness (Mendis et al, 1998). By using microarray technology we have identified a panel of host genes that are up-regulated or down-regulated in response to various BW agents such as Anthrax, plague, Brucella, VEE, Cholera toxin, Botulinum and 2 shock inducing toxins staphylococcal enterotoxin B (SEB) and lipopolysaccharide (LPS). We have also used this gene profile for infection with dengue virus 2. The objective of this topic is to verify the specificity of gene expression profiles obtained for host responses to biological warfare agents after comparing it with common inflammatory diseases to develop a reliable diagnostic assay. Inflammation is the first physiological response induced in the host upon biological warfare agent exposure. Therefore our hypothesis is that some of the genes that we characterized as uniquely altered in biological warfare agent exposure may be also altered in some of the more common inflammatory diseases. In order to develop a robust diagnostic assay using these gene profiles as markers we need to be sure that the genes that are turned on in the host by biothreat agents are not affected by common illnesses.

Our group at WRAIR have identified genes that will for example differentiate influenza from anthrax. We have also identified genes that are never expressed in the control untreated samples, however they are altered upon exposure to these various biological threat agents. These genes expression profiles can be measured early in the disease process and used as a diagnostic tool for detection of exposure to such agents. It is therfore important to understand and analyse host responses to common inflammatory diseases to create a unique and reliable diagnostic assay for our biodefense program. This is a high risk research effort and not a mere procurement. The outcome of this research effort will be a better diagnostic assay for detection of biothreat exposure and may be detection of various common illnesses as well.

Development of simpler procedures for rapid diagnosis of exposure to these biological threat agents through the detection of host gene responses have broad range of applications in other areas of military and civilian concern. Development of such robust assays will have a great impact not only on civilian readiness to combat bioterrorism but also provide a tool to treat other infectious diseases and detect exposure to toxic agents in the environment. This technology can therefore be considered for the dual use science and technology (DUST) and the dual use applications program (DUAP).

PHASE I: The goal is to identify human response genes for a common inflammatory disease. For Phase I the company will perform research to obtain information on how the body's immune cells respond when they have a common inflammatory illness. These responses can be measured by looking at the gene changes in a global way, which means not just measuring gene changes for one or two genes but measuring gene changes for 100-1000 genes at a time. The gene changes can be measured by various techniques available today for high throughput screening of gene expression profile from patients affected with a common inflammatory disease. These assays should be highly reproducible, sensitive and robust for measuring these gene expression changes. Proof of concept can be determined by developing an assay to identify a panel of genes (100-1000) altered for one inflammatory disease compared to control non diseased samples, the results should be statistically significant and they should be reproducible.

PHASE II: The assay developed in Phase 1 will be used for analyzing gene changes from multiple patient samples with common inflammatory illnesses. Expand the type of illness studied from one to many such common inflammatory diseases. Gene profiles determined for each of these inflammatory disease will be incorporated into a database. Upon obtaining and analyzing the results from collaborators compare them with our panel of genes identified from biothreat agents. This will enable us to make sure the genes identified to be altered by inflammatory diseases are different from the panel of genes identified for BW agents. These genes will be ultimately used for a diagnostic chip to detect exposure to biothreat agents. Exit criteria will be to successfully demonstrate the expected changes in gene expression profiles specific for that common disease by screening blinded samples. Put these selected genes on a platform for development of a rapid diagnostic assay. Adapt this assay for other biological threat agents and common diseases.

PHASE III DUAL USE APPLICATIONS: The information obtained from the measurement of changes in gene expression profile will be of great help in designing better diagnostic assays. This assay will not be restricted to exposure of biological agents but will be applicable to any infectious or common illnesses. The information obtained from these studies will be used to design a diagnostic chip for rapid detection of common inflammatory illnesses and exposure to biological threat agents. This type of a rapid and sensitive diagnostic tool is much needed in today's world and will be of great value commercially to both the defense and civilian community.

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KEYWORDS: Gene expression profiles, host response genes, microarray, inflammatory diseases, rapid diagnostic tests.

A03-165 TITLE: Accelerated Drug Design Through Computational Biology

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: The objective of this SBIR topic is to enhance rational, structure-based drug design efforts by exploiting the novel technology emerging from the bioinformatics field. We seek lead compound identification through the use of computational models, specifically considering candidate proteins from the malaria-causing parasite Plasmodium falciparum currently being studied. Identification and optimization of lead candidates for antimalarial drug discovery supports the DoD?s Biomedical Technology Area program in Infectious Diseases of Military Importance.

DESCRIPTION: In order to make predictions about potential chemical inhibitors, the structure of the target molecule in question is critical. Current technologies used to determine protein structure, including X-ray crystallography or NMR, are slow and limited only to proteins that can be stably expressed and highly purified in significant amounts. The generation and subsequent analyses of these structural models are limiting factors in structure-based drug design, and new technology aimed at circumventing these limitations is required to enhance current drug discovery efforts.

The focus of this effort is to gain molecular information that will advance current candidate drug screening efforts by improving the selection criteria of compounds analyzed. In order to avoid the limitations associated with current structure-based drug design methodologies, specifically determining protein structure by physical analysis, we seek the development of new technology to conduct such analyses using a bioinformatics approach. Requirements include the generation and analysis of surface structure models from primary DNA or amino acid sequence with resolutions at or near that of crystallographic resolution, to include any accessory molecules required for protein function. Further requirements include the ability to analyze these models and provide structures of potential inhibitory molecules that can be synthesized and transitioned into current drug discovery programs. Key aspects of this analysis should consider: 1) the identification of compounds that are specific for the target protein and are not predicted to inhibit any homologous human proteins, and 2) exploit regions outside of the active site of a target protein that may be suitable of chemical inhibition. The ability to synthesize these novel compounds in quantities sufficient for biological characterization (milligram) will be positively considered but is not absolutely required. Rational drug design will focus our current screening efforts to allow for the better utilization of limited funding . This will increase our capacity to characterize critical inhibitors and identify potential lead compounds, thus expediting the drug discovery process. This technology will provide critical data for and transition into existing drug discovery programs and may be further exploited to encompass additional, potentially new drug targets in P. falciparum as well as other organisms central to infectious disease research of both DoD and civilian importance.

PHASE I: Propose a system to use computational methodologies to: 1) generate molecular models of various target proteins, and 2) use these models to design/identify novel chemical inhibitors. Validate the system using the sequence of P. falciparum MRK or PK5 for which inhibitory data for specific compounds have been previously been determined.

PHASE II: Utilize the system validated in Phase I to generate molecular models of additional target proteins for which there is limited inhibitor data available. Provide molecular models and structures of compounds, or families of compounds, that could serve as novel chemical inhibitors to be used in conjunction with high-throughput drug screening efforts.

PHASE III DUAL USE APPLICATIONS: The exploitation of bioinformatically-derived information has the potential to yield significant advances of military and civilian importance both in drug discovery as well as other areas of biomedical research. In addition to serving as the foundation for structure-based drug design, the ability to structurally analyze proteins in silico will enhance any project where molecular analysis is vital. Potential areas of research that could benefit include examining the effects of mutations on the emergence of drug resistance, enhancing our understanding of the molecular interactions of chemical and biological agents with target proteins, and the more effective design of antigens/antibodies for vaccine research.

ACCESS TO GOVERNMENT SUPPLIES: The design of chemical inhibitors indicated in Phase II may be faciliated by support from the Walter Reed Army Institute of Research. The candidate contractor should coordinate with the COR for any required support prior to the submission of the proposal.

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4) Xiao Z, Waters N C, Woodard C L, Li Z, Li P. Design and synthesis of pfmrk inhibitors as potential antimalarial agents. 2001. Bioorg Med Chem Lett 11:21 2875-8.

KEYWORDS: Structure-based drug design, molecular modeling, bioinformatics

A03-166 TITLE: Development of Bioassays for Prion Infectivity Using Human, Deer, or Elk Cells

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Develop a human, deer, or elk cell culture model for prion propagation that can be used as a bioassay for detecting prions.

DESCRIPTION: There is significant need for better methods to detect prion-related diseases that cause transmissible spongiform encephalopathies (TSE). Current infectivity bioassays involve the use of mice or hamsters. A cell culture model for prion propagation could lead to the development of a reproducible model for studying the mechanism of prion infectivity and disease. Additionally, a cell culture model for prion propagation could be used as an assay for the screening of potential prion therapeutics and could replace the animal test with a more rapid and sensitive cell-based diagnostic assay.

Research will be directed toward the development of novel human, deer, or elk cell-based models for prion propagation. The cell model can consist of primary and/or engineered cell lines or co-cultures that have been optimized to support the propagation of prions. The inclusion of secondary cell types and/or other biological factors that support the purpose of the model is encouraged. Methods that are both sensitive and specific for detecting prion infection in the cultured cells must also be identified. Collaborations to develop the cell model for prion propagation and the infectivity detection assay are encouraged. The test method developed must be sensitive, specific, reproducible, and timely. Innovative concepts are highly encouraged.

PHASE I. Select one species, either human, deer, or elk, for the development of cell lines. Create several novel cell lines from the selected species that support prion propagation at detectable levels. A sensitive and specific method to detect prion propagation in the cultured cells is essential to demonstrate the proof-of-principle.

A detailed and specific plan for access to cells and/or tissues for the selected species must be provided in the application. A detailed and specific plan for the tissue and types of cells that will be used, and how the cell lines will be developed must also be included. Alternative approaches should be discussed, and the selected approach justified. Potential technical problems should be identified and addressed.

Collaboration/subaward with a lab that has access to and capabilities in prion research is encouraged for the development of the detection assay.

The use of human cells and tissues and/or animal use will require approval by the appropriate USAMRMC regulatory board.

PHASE II. The objective of Phase II is to develop and validate a bioassay for detecting prions in tissues and body fluids. This bioassay will include a single-cell or co-culture cell model and a detection assay. Using the species-specific cell culture(s) developed in Phase I, continue to optimize the cell model(s) and the prion detection assay. Evaluate the single-cell or co-culture model(s) for infectivity, prion propagation, and assay sensitivity. Concurrently, if more than one prion detection assay is being used/developed, then compare the assays using the different culture model(s). Select the most promising cell model and detection assay, and optimize the infectivity, sensitivity, and specificity of this bioassay. Validation of this bioassay will consist of benchmarking the results to a currently accepted animal model, and demonstrating the bioassay is sensitive, specific, and reproducible.

PHASE III: The commercialization potential of the resulting cell model and bioassay is high and is an important consideration in both the military and civilian environments. The assay system for detecting prions should be applicable to assessing the food and blood supply. Analysis of animals at the time of slaughter, screening of live animals, and early detection of prions in humans and animals, and blood products are several applications of this technology. Moreover, this assay technology will be important to the research study of prions. Proof of principle in Phase II should be sufficient to facilitate marketing of this assay to pharmaceutical or biotech companies possessing the capability of completing assay kit development and any required FDA approvals.

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1. Ingrosso, L., Vetrugno, V., Cardone, F., and Pocchiari, M. Molecular diagnostics of transmissible spongiform encephalopathies. Trends in Molecular Medicine: 2002, 8:273-280.
2. Collinge, J. Prion diseases of humans and animals: Their causes and molecular basis. 2001, 24:519-50.
3. Prusiner, S. Prions. Proc. Natl. Acad. Sci USA. 1998, 95:13363-13383.

KEYWORDS: Prion diagnostics, prion propagation, infectivity bioassay, diagnostics, cell culture model, neural cell model

A03-167 TITLE: Innovative Manufacturing Techniques for Polysaccharide-Protein Conjugate Vaccines

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Develop an economical manufacturing process, compatible with current Good Manufacturing Procedures (cGMP), for production of conjugated Shigellla polysaccharide-protein vaccines. Chemically conjugated vaccines consisting of a bacterial surface polysaccharide and a protein carrier have been shown to protect Israeli soldiers from diarrhea caused by Shigella sonnei after a single intramuscular injection (Lancet

1997;72:155-9). S. sonnei is the most prevalent cause of bacillary dysentery effecting U.S.. S. soldiers deployed in the Middle East (New Engl. J. Med. 191;325:1423-8). Phase I trials of polysaccharide-protein conjugate vaccines prepared from S. flexneri and S. dysenteriae 1 have suggested that other etiologically important Shigella species could also be prevented using this technology (Infect. Immun. 1993;61:3678-3687).

DESCRIPTION: The main impediment to Shigella conjugate vaccine development is absence of an efficient, commercially viable manufacturing process yielding a product that could be licensed by the FDA. The polysaccharide component of conjugate vaccines is derived from Shigella lipopolysaccharide (LPS), which is tightly bound to the bacterial cell wall. LPS is extracted from bacteria using hot phenol – a laborious and expensive process with small product yield and high toxic waste output. The LPS must also be detoxified by removing the lipid component before conjugation with a protein carrier as the final step in vaccine manufacture. The DoD requires innovative approaches to the specific problems of bacterial LPS extraction, purification, detoxification, and chemical conjugation under cGMP. The manufacturing process should be economical and environmentally friendly (i.e. not employing caustic chemicals such as phenol). Injected Shigella polysaccharide-protein conjugate vaccine(s) would be widely used by deployed United States troops and by allied troops. In addition, civilian travelers to the developing world and children living in endemic areas constitute a large civilian market for these vaccines.

PHASE I: Process development demonstrating economy, scalability and compatibility with cGMP conditions should also be accomplished in Phase I. The output ofa successful Phase I SBIR would be a research prototype S. sonnei or S. flexneri 2a conjugate vaccine with the chemical characteristics of a safe an immunogenic product. The manufacturing process should be cGMP compatible, but cGMP manufacture would not be expected in phase I. Animal testing demonstrating the safety and immunogenicity of the non-cGMP prototype conjugate vaccine would also occur in Phase II.

PHASE II: This phase would begin with toxicity and immunogenicity studies on the research prototype conjugate vaccine product in animals. Demonstration of safety and immunogenicity of the prototype conjugate vaccine would support cGMP manufacture of a pilot lot of vaccine. The Phase II output would be an S. sonnei or S. flexneri 2a conjugate vaccine manufactured under cGMP for human use. Final chemical characterization, animal toxicity testing, and immunogenicity testing of the cGMP product should also be accomplished under the Phase II contract, and the product would be a successful Investigational New Drug (IND) Application to the FDA.

PHASE III: The fully characterized cGMP conjugate vaccine product would be evaluated as an intramuscular vaccine in clinical trials under IND. Both safety and efficacy of the prototype vaccine in a Shigella challenge model should be assessed in these trials. Since the product would have commercial potential as a vaccine for deployed military personnel and for travelers in the developing world, commercial interests could fund early clinical trials. However, Shigella vaccines are needed for children of the developing world, and the public health sector (e.g., the Bill and Melinda Gates Foundation and/or the World Health Organization) are also interested in funding clinical development of economical conjugate vaccine(s). Ultimately a licensed vaccine against diarrheal disease for use in both the developed and in the developing world will require a combination of private and public funding.

KEYWORDS: Shigella, conjugate vaccines, manufacturing process development

A03-168 TITLE: <u>Anti-Microbial Nanoparticles Composed of a Magnetic Core and Covered with Photocatalytic TiO2</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: The overall goal of this project is to develop a new generation of photocatalytic particles that can be applied topologically and irradiated with UV light for the purpose of disinfecting wounds. These nanoparticle photocatalysts have a magnetic core, which permits their complete removal after treatment.

DESCRIPTION: $TiO_2$ semiconducting photocatalysts, when irradiated with UV light, produce electron-hole pairs that can initiate reductive and oxidative reactions on the surface of these materials. An excellent review of photocatalysis in both the gas and liquid phase has been written by Mills and Lehunte. The holes, by virtue of producing OH radicals or through direct charge injection, are highly oxidizing and can be used as an anti-microbial agent. Nanoparticles of $TiO_2$ can be routinely produced with dimensions of 3-8 nm suspended in aqueous-based solvents. Such materials can be directly sprayed on to wounds to decrease infection. Unfortunately, $TiO_2$ particles are electrical insulators, and it is likely that it would be difficult to extract these nanoparticles from the wound after treatment! Therefore, this project is focused on producing a new class of removable nanoparticle photocatalysts that can be completely extracted from the treatment area by using a magnetic field.

The successful completion of this project would produce a new generation of field-applied, sprayable, antimicrobial nanoparticle photocatalysts that would help to keep wounds clean of bacteria and could easily be removed after treatment. While nanoparticles of magnetite have been prepared there are no references to the coating of these magnetic core particles with photocatalysts. The first emphasis of this project is to produce these novel particles that have the potential of being applied topologically to reduce bacterial infections in wounds. Our desire is to create a sprayable form of this photocatalyst that can be easily applied and as easily removed with a magnet. Therefore, our first objective is to develop procedures for effectively coating magnetite nanoparticles with nanoparticulate $TiO_2$. This will effectively produce an active photocatalytic therapeutic agent that can be easily sprayed on to a surface. We believe that this task can be accomplished within the first three to four months of this project.

These coatings can be tested in a variety of ways: Firstly, coatings can be tested using electrophoretic mobility methods. Magnetite particles display a given charge vs pH signature. $TiO_2$ particles have a different signature. If completely coated with magnetite with $TiO_2$, the composite particle will show a signature that is representative of the outer coat. This essentially insures that the nanoparticle magnetic core is completely covered with our photocatalytic, antimicrobial coating. Secondly, a magnet will be use to determine if these coated particles can be removed from a suspension. The effectiveness of the removal can be tested by analyzing the $TiO_2$ remaining in the suspension after the magnetic field is applied. In yet another test, we can measure the photocatalytic activity of these materials by spraying films of these magnetic-core photocatalysts on glass slides and performing gas-phase tests to determine the ability of these coated slides to destroy organics (ref).

PHASE I :

1. Making magnetite ($Fe_3O_4$) core particles: Produce a colloidal form of magnetite having particle diameters of ca. 10nm or less. One possible approach is that of Rosenwieg.

2. Characterizing magnetite particles: Electrophoretic mobility to characterize the zeta potential of the particles as a function of pH. This measurement will provide a fingerprint of the surface charge of these particles. SEM and X-ray methods can be used to characterize size, morphology and crystalline habits of these materials.

3. Coating magnetite particles with $TiO_2$: The method of $TIO_2$ coating of the magnetite particles must be able to form a complete cover. A method such as electrophoresis may be used to demonstrate magnetite saturation with $TIO_2$.

PHASE II:

4. Measuring photocatalytic activity of the coated particles: Simple gas –phase testing methods should be used to determine if in fact these materials are photocatalytically active. Coat glass slides should be coated with the suspensions produced in Task 3. These coated slides will then be placed in a gas-sampling system connected to an infrared spectrometer. Upon UV-irradiation of the coated slide, a volatile organic contaminant such as ethanol should degrade to form carbon dioxide if the coated particles have photocatalytic activity.

5. Testing removal using magnetic fields: In this study, particles will be removed from suspensions containing known particle concentrations using a bar magnet. Test the removal efficiency by using inductively coupled plasma atomic absorption spectroscopy to measure the amount of Ti remaining in the suspension. This approach will determine if all of the particles have been removed in a given time.

PHASE III: Studying the potential as a surface and liquid sanitizer activated by sunlight for commercial use. The suspensions should be placed in pump-spray or aerosol vessels for delivery. It is envisioned to test various topical concentrations as well as selected light intensities by moving the UV source nearer to or farther from the area of application. These materials can then be sprayed onto real wounds. Direct (application self or buddy) to open surface wound that will have antimicrobial activity when exposed to sunlight or visible light and can be combined with wound dressings to keep exposed dressing surfaces from being a source of environmental contamination penetrating to the wound. Also, the magnetic properties can be used to concentrate the nano-particles and also remove them when needed. Commercially, the potential exists for specifically localizing injected magnetic particles in hospitalized patients with magnetic fields such as MRI or other magnetic scanners and then using a fiber of laser to excite therapeutic activity.

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KEYWORDS: Antimicrobial, Nanoparticles

A03-169 TITLE: Programmable Wrist-Worn Prediction Model and Environmental Stress Monitor

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Design and build a low cost, programmable wrist-worn environmental monitoring system with in built high quality, high performance, inexpensive Analog and Mixed Signal Application Specific Integrated Circuits (ASICs) for physiologic/thermoregulatory model output to assess individual warfighter physiologic responses to a variety of environmental stresses. The technical challenge is integration of key predictive mathematical algorithms to deployable environmental sensors and that displays predictive real-time outputs in a low power drain, rugged weather resistant package that does not exceed the size of a wristwatch and is non-intrusive to the warfighter.

DESCRIPTION: A wristwatch size environmental heat/cold stress activity monitoring system with key ASICs to assess individual warfighter readiness across a wide range of military operational settings. Existing technology incorporates predictive heat stress algorithms and environmental sensors in a pocket-sized device for use at the small unit level, but outputs, which consider heat stress only, are based exclusively on detached, bulky environmental measurements, and depend on user estimates of average activity and other input parameters. The proposed wrist-worn device will provide the capability to estimate activity monitoring coupled with a physiologic servo-loop thermoregulatory model to quantify metabolic expenditures. In built ASICs will enable personalized predictive estimates of the physiologic responses to activity, clothing system and environmental stressors in real-time operational settings. Contractor will have wide discretion in selection of methods and materials as long as key functional requirements are met. A water resistant, rugged enclosure with optimized sensor placement will have a liquid crystal display and control buttons for selecting functions and data display modes. Environmental sensor suites can be deployed from the watch head to provide ambient temperature, humidity, wind speed, and solar irradiance for use as input to a physiological model output source. The device will have sufficient memory to store 72 hours of measured data and/or computed indices for subsequent display, download, or network transmission. Total weight will not exceed 2 ounces (56 grams) and battery life will be sufficient for at least 7 days of sustained operations by a person. Target environmental sensor accuracies should be within these tolerances: Air temperature + 0.5 C, humidity +5%, and solar irradiance + 100 Watts/m2. The activity sensor should accommodate both sleep scoring (zero crossing) and daytime activity (proportional) modes of operation. Additional micro-sensors to measure skin temperature and/or heart rate would significantly enhance operational potential of the device. The device will have primary functionality as a "smart" environmental sensor suite capable of integration and/or fusion in a network of lightweight, wearable body sensor systems. The device will have I/O ports to allow communication with a PC or network hub. The developed system will include supporting personal computer software to enable download of data and upload or direct programming of specialized performance or environmental stress index algorithms such as Cold Stress Index (CSI) and Physiological Strain Index (PSI) for near real-time determination of thermal performance in various Objective Force Warrior scenarios.

PHASE I: Develop overall system design document, to include a high level hardware firmware/software, power budget, integrate a multi-node thermoregulatory model, PC support software interface, and smart sensor/network integration requirements. Phase I may also include initial proof-of-concept hardware and software prototypes detailing prediction model algorithms.

PHASE II: Build no more that 10 working prototypes and supporting hardware/software interfaces suitable for full scale performance evaluations in the laboratory or field. The working prototypes must have a simple thermoregulatory model allowing output of simulated water requirements, work/rest cycles and maximum work times from the given environmental sensor sweeps, clothing system menu, and activity level. The end point is to merge with WPSM product technology integration for a facile, near real-time deployable environmental sensor suite capable of simulation of soldier performance.

PHASE III DUAL USE APPLICATIONS: The system would have significant potential for use in real-time physiological response monitoring of HAZMAT and firefighting applications, for evaluating micro-environments for individual firefighters exposed to warm environments, and for judging relative risks associated with diverse activities, environments, and clothing challenges. The system may also have commercial applications in the bus or truck driving industries, bomb disposal, and helicopter cockpit environmental assessment.

KEYWORDS: Environmental sensor suite, algorithms, ASICS, physiologic prediction models, cold stress, heat stress, micro scale environment

A03-170 TITLE: Patient Safety Perioperative Readiness Support System

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Develop an interactive PC based system for employment in the perioperative environment; capable of providing explicit patient tracking, monitoring of physiological data of all patients and readiness status of all relevant medical personnel and support systems. Seven key components should assist in providing a focus for this research agenda. The intent is to develop new knowledge by building on extent knowledge related to human factors and error reduction strategies.

DESCRIPTION: Background of the Problem
Clinicians caring for surgical patients strive to ensure patient safety while providing quality care. However, existing evidence suggests that both medical and surgical errors are excessive in the current health care system. A particular concern is the fact that “surgical errors often appear the worse…The end points in surgery are often more concrete and immediate than in medicine – survival or death, cure or failure” (Hettiaratchy, 2001, p. 887). Limited information exists regarding the exact incidence and nature of surgical errors and adverse events, and even less is known about actions and interventions that promote and ensure patient safety.

PHASE I: Provide appropriate research and analysis to facilitate a definitive understanding of the true nature and incidence of adverse events in Operating Rooms/Surgical settings, building on extensive knowledge related to human factors and error reduction strategies. Assess adverse events in the perioperative environment (space utilization); system failures, team-work, communications and leadership. Provide a detailed illustrative report that identifies safer and more effective clinical processes resulting from the initial research and analytical findings.

PHASE II: Design, develop and demonstrate a functional prototype of a full performance PC based interactive system for employment in the perioperative environment. The system will be capable of explicit patient tracking, monitoring of physiological data of all patients and readiness status of all relevant medical personnel and perioperative support systems. The system will have the ability to provide virtual perioperative readiness support system updates on an interactive 'white board' that is accessible to all personnel in the perioperative environment.

PHASE III DUAL USE COMMERCIALIZATION: The value of this research will be to provide new knowledge and understanding to clinicians in military and civilian surgical settings, as well as to provide the perioperative team with an interactive monitoring system that will help and assist in managing the operating room. The ultimate goals are to facilitate and enhance perioperative team awareness, patient safety and logistical preparedness.

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KEYWORDS: Patient Safety, Surgical Settings, Adverse Events, Surgical Errors, Inpatient Surgery, Post Operative, Governance/Leadership, Process Implementation, Learning Environment

A03-171 TITLE: Multimeric Protein Malaria Vaccine

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

Objective: Design, create and test platforms that create multimeric proteins to improve the immunogenicity of the E.coli expressed protein vaccine candidate PfMSP1-42(FVO).

Description: Malaria remains one of the most widespread of human pathogenic diseases in Africa, South America and Southeast Asia. Not only does this disease have a heavy impact on endemic populations, killing more than 1 million children annually, it also strongly affects US military peacekeeping and humanitarian missions in these areas. Apart from these needs, businessmen and tourists traveling to malaria endemic areas would also benefit from an antimalarial vaccine.

The 42 kDa C-terminal fragment from Plasmodium falciparum Merozoite Surface Protein 1, known as PfMSP1-42 expressed in E. coli is safe and immunogenic, and when administered in conjunction with Freund's adjuvant, it induces the strongest protective effect measured to date in an Aotus monkey challenge trial (manuscript in preparation). In one such trial four of six animals self-resolved their infections, and two suppressed parasitemia but required treatment for anemia. This result contrasts with another vaccine tested in the same trial based on the same protein produced in a baculovirus expression system (1). In this later group, only one of five animals self-resolved infection, two were treated for uncontrolled parasitemia, and the other two were treated for anemia. The reduced efficacy of the baculovirus-expressed antigen is probably due to protein glycosylation (1), which suppresses induction of immunity by this antigen. Other adjuvants did not induce protective immunity in our trial.

MSP1 may physically exist in a multimeric state rather than a monomeric state on the merozoite surface, and thus an optimal vaccine may have to replicate this structure. This hypothesis has not been addressed in the peer reviewed literature, but it is supported by our observation that functional mAbs have increased binding strength to aggregated antigen compared to monomeric antigen, and that during chromatography the E. coli MSP1-42 (FVO) antigen appears to behave as a multimer. The current effort would develop multimeric PfMSP1-42 (FVO strain) expressed in E. coli, with the objective of improving immunogenicity and protection against malaria parasite infection. Improved immunogenicity would be measured by increased induction of functional antibodies that inhibit parasite growth (2) or inhibit proteolytic processing of malaria merozoite derived PfMSP1-42 in vitro (3), and would provide increased protection in the Aotus challenge model. Such antibodies would be induced by vaccination of animals with Freund's adjuvant but more importantly with adjuvants that have strong potential for human use.

Phase I: Develop a prototype of the biochemical components of the multimeric PfMSP1-42(FVO) vaccine. As a proof of principle of the biochemical part of the project, perform the initial characterization of the multimeric protein, and show that multimerization does not disrupt or make inaccessible the conformational "inhibitory" epitopes on MSP1-42 (FVO). Additionally provide a theoretical justification as to why this approach and compatible adjuvants might be considered safe for human use by the FDA.

Phase II: Complete the development of the biochemical components of the multimeric PfMSP1-42(FVO) vaccine, and show that functional monoclonal antibodies that react with conformational epitopes on MSP1-42 (FVO) bind to the multimer with affinity that is at least equal to that of binding to monomer. Compare immunogenicity of monomeric and multimeric MSP1-42 given with Freund's adjuvant and adjuvants that are suitable for human use. Success will be significant increases in induction of functional antibodies by multimeric antigen compared to monomeric antigen. The best performing adjuvants will be selected for an additional comparative study conducted in Aotus monkeys with P. falciparum challenge and will include Freund's Adjuvant groups as the reference standard.

Phase III: A successful malaria vaccine will have important application not only meeting DOD objectives, but also as vaccine strategies for residences of malaria endemic areas, as well as for business travelers and tourists.

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[3] Blackman MJ. Purification of Plasmodium falciparum merozoites for analysis of the processing of merozoite surface protein-1. Methods Cell Biol 1994;45:213-20.

KEYWORDS: Plasmodium falciparum, malaria, vaccine, Merozoite Surface Protein, Adjuvant, human use

A03-172 TITLE: Angiogenesis Targeted Drug Development

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA,MRMC

OBJECTIVE: Develop Novel Therapeutic Strategies for Pharmacological Intervention of Angiogenesis

DESCRIPTION: Angiogenesis, the process by which new blood vessels are formed, is a complex sequence of events that is fundamental to many physiologic and pathologic processes such as tumor growth, and vascular and chronic inflammatory diseases. Generation of new blood vessels plays dual but opposing roles in biology. While stimulating angiogenesis may be beneficial in the treatment and healing of battlefield injuries, surgical wounds and ulcers (1), inhibiting excessive blood vessel growth may be critical to delaying or halting the progression of diseases such as cancer (2), diabetes retinopathy, rheumatoid arthritis and inflammatory bowel disease. With the identification of a number of proangiogenic molecules such as the vascular endothelial cell growth factor (VEGF), the fibroblast growth factors (FGF) and other inhibitors of angiogenesis such as angiostatin and endostatin, it is recognized that therapeutic intervention with vasculature formation offers unique drug targeting opportunities for the treatment of cancer, heart and vascular diseases, and chronic inflammation (3). Agents/drugs that stimulate angiogenesis may also find immediate military application in the treatment of injuries by reducing the morbidity and facilitating a shorter course of rehabilitation for soldiers deployed in the battlefield. The challenge remains with identifying specific molecular targets in the angiogenesis process and applying technologies to design and develop various agent/drug candidates directed toward those molecular targets. Agents/drugs that either stimulate or inhibit angiogenesis may serve as important pharmacological tools for intervening during the healing process or disease progression, respectively (3).

The goal of this solicitation is to develop new agent/rug candidates using the knowledge of molecular targets involved in the angiogenesis process. Applying new technologies such as phase display, serial analysis of gene expression (SAGE), and systematic evolution of ligands by exponential enrichment (SELEX) may be useful in this endeavor.

Phase I: Identify several new agent/drug candidates targeted toward angiogenesis. The methodology to identify molecular targets, and the rationale for designing the effector molecular entities such as small molecules, peptides, oligonucleotides, ribozymes, antibodies, drug conjugates, immunological agents etc, should be elaborated.

Phase II: Initiate evaluation of several agent/drug candidates in biological assays and preclinical animal models.

Phase III: Perform additional experiments with the lead targeted agent(s)/drug(s) to prepare for FDA review, and approval, and subsequent commercialization. The molecular-targeted agent/drugs identified and the technologies developed should yield many advances important not only to the civilian but also to the military community. Identifying and developing agents/drugs that stimulate new blood vessel formation and enhance the oxygenation of damaged tissues should have an enormous impact on wound healing and the treatment of injuries such as surgical wounds and fractures.

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KEYWORDS: Angiogenesis, drug targeting, vascularization, wound healing.

A03-173 TITLE: Amplification of Proteins in Body Fluids for Early Detection of Biological Warfare Exposure

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: The overall objective is to detect very low levels of multiple pathogen- specific proteins (or perhaps host responses) very quickly after exposure. In the case of B. anthracis exposure, various proteins (lethal factor, edema factor, etc) are released but the quantity is low until onset of serious disease consequences. Proteins studied should be associated with a BW agent from the CDC "A" list.

DESCRIPTION: Effective prophylaxis and treatment for infections caused by biological threat agents rely upon early diagnosis and rapid initiation of therapy. However, most methods for identifying pathogens or infectious agents in body fluids and tissues require that the pathogen proliferate to a detectable level, which might take days to weeks, thereby delaying diagnosis and treatment and putting the patient at increased risk of morbidity and mortality. In an effort to detect such exposure more rapidly (within hours), during the prodromal or even prepatent stages, we found that certain gene expression patterns were unique to each pathogen and that other gene changes occurred in response to multiple agents, perhaps relating to the eventual course of illness. Although gene expression patterns can serve as diagnostic markers for predicting the course of impending illness and may lead to new stage-specific therapeutic strategies to ameliorate the devastating effects of exposure to biological threat agents, it may be useful to identify either pathogen or host-specific proteins as early markers of exposure.

PHASE I: Identify specific binding entities (aptamers, antibodies, etc) to 3 very low level proteins. Develop a method to encorporate distinguishing amplifiable material (such as DNA) into the binding entities, specifically amplify only the tagged entities bound to the proteins of interest, standardize appropriate amplification methods of those proteins. Our laboratory will provide body fluids from animals studies of exposure to selected biological threat agents.

PHASE II: Utilizing the technology developed in Phase I, apply the principle for development of a multiplex/high throughput assay to be able to differentiate among ~20 proteins in a single mix, to include those proteins that can provide even greater certainty that exposure was due to the biothreat agent rather than to a "common" infectious agent. Our laboratory could provide body fluids from animal studies of exposure to selected biological threat agents in order to further expand the range of proteins that encompass the prodromal period through the early stages of illness. Selection of specific proteins will be justified by bioinformatics and will be submitted for approval.

Qualifications:
a) The contractor will have the expertise to develop protocols for constructing and attaching discriminating tags (such as DNA) to the aptamers/antibodies, etc, that will bind specifically to protein moieties. b) Amplification of the protein-aptamer/antibody-TAG complex will have to be optimized, and turned into highthroughput assays. c) Scientists at the company/contractor will have vast experience in the fields of molecular biology, multiplexing/highthroughput technology and proteomics. d) Bioinformatics knowledge and capabilities will also contribute to the project's challenges.

PHASE-III: DUAL USE APPLICATIONS: The information heavily relies on identification of proteins that will discriminate biothreat from "common" illnesses and therefore is not restricted to exposure of biological agents but is applicable to any infectious or common illnesses. The information obtained from these studies will be used to design a diagnostic tool for detection of infectious diseases, common inflammatory illnesses and exposure to biological threat agents. This type of a rapid and sensitive diagnostic tool is much needed in today's world and will be of great value commercially to both the defense and civilian community.

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2. Ionin, B., Foley, J., Lee, D., Das, R., and Jett, M. (1999). Differential gene expression pattern induced by staphylococcal enterotoxin B in human kidney cells. Abstract #443. FASEB Journal 13:A1407.
3. Das et al (2002) Host gene expression profiles in peripheral blood mononuclear cells: Detection of exposure to biological Threat Agents. In Proceedings of the 23rd Army Science Conference, KO-04.

KEYWORDS: proteomics, aptamers, amplification methods, host response profiles

A03-174 TITLE: <u>Advancing Training Techniques of Non-Invasive 3-Dimensional Ultrasound Sound Technologies for both Diagnostic and Therapeutic Applications</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Currently, technology advancements are focused on reducing the cube and weight of current ultrasound devices providing easy to use high frame rate ultrasound scanners through improved transducer array designs that offer for both three-dimensional diagnostic imaging and therapeutic applications in diagnosing and treating blunt and/or ballistic trauma. These efforts have taken into consideration the infrastructure necessary to provide both ruggedization, as well as configuration to military field sites. However, the human-machine interface on the battlefield has not been explored sufficiently to best determine ultrasound's potential impact as a force multiplier providing tertiary level health care across the echelons of care.

Therefore, this proposal is to develop training techniques for using ultrasound imagers due to the difficulty of reading diagnostic ultrasound scans and thus its limited utility in far-forward conditions in which lower-skilled medics would have to acquire and transmit these scans to higher-skilled clinicians.

DESCRIPTION: It is desired to have a visual anatomic guidance system that will provide military personnel expert assistance in performing diagnostic and therapeutic medical ultrasound in injured or sick personnel in forward echelons. The recent availability of hand-held diagnostic ultrasound devices have limited utility because the difficulty of training medics to obtain and interpret images of diagnostic quality. A goal of this solicitation is to mitigate the training requirement by providing active computer assistance that visually displays to the medic how the image plane moves toward the specified anatomic location as s/he manipulates the ultrasound probe over the combatant's body. The system should also enable experts in a remote telemedicine facility who are reviewing the initial images to direct the medic in acquiring additional images in specified anatomical locations to facilitate diagnosis and triage. The same display could also be used to guide therapeutic ultrasound for hemostasis.

PHASE I: The proposal for Phase I should focus on a Research and Development Design Plan to include commercial viability and whether a completely new device or a modification of current technology will be most cost effective. Conduct a thorough technology search to to determine availablity of commercial devices/products requiring modification versus the need to develop an entirely new product prototype. During Phase I, any requirement for the use of animal and/or human models will be identified and local IRB and government RCQ protocol approvals will be granted prior to any clinincal trials.

PHASE II: In this phase an actual prototype would be developed at the breadboard or work bench level.

PHASE III DUAL-USE COMMERCIALIZATION: This phase will pertain to completion of a prototype at the beta level and a commercialization plan for a commercially viable product to include FDA clearance and cost/benefit analysis. Cost sharing between the government and the commercial sector will only maximize funding and viability of this effort.

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1) Sapin P M, Schroeder K M, Gopal A S, Smith MD, King D L. Three-dimensional echocardiography: Limitations of apical biplane imaging for measurement of left ventricular volume. J Am Soc Echocardiogr 1995;8:576-584.
2) King D L, Harrison M R, King D L, Jr, Gopal A S, Martin R P, DeMaria A N. Improved reproducibility of left atrial and left ventricular measurements by guided three-dimensional echocardiography. J Am Coll Cardiol 1992;20:1238-1245.
3) Martin R W, Vaezy S, Kackowski P, Keilman G, Carter S, Caps M, et al. Hemostasis of punctured vessels using Doppler-guided high-intensity ultrasound. Ultrasound Med Biol 1999;25:985-990.

KEYWORDS: ultrasonography, non-invasive, diagnostic imaging, therapeutic, hemostasis, transcranial ultrasound, hand-held

A03-175 TITLE: <u>Portable Test for Detection of Viruses in Arthropod Vectors</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

STO: STO IV.ME.2000.08 Replacement of the Standard Military Insect Repellent

OBJECTIVE: To produce a device for rapid, portable, and cheap detection of dengue and other viruses in arthropod vectors.

DESCRIPTION: A membrane-bound wicking assay requiring no refrigeration that produces accurate (sensitivity >

95%; specificity > 95%) identification of dengue (either serotype specific or not) in individual or pooled (at least 10) vector mosquitoes. Application of similiar technology in separate assays for Japanese encephalitis, Ross River virus, Rift Valley fever virus.

PHASE I: Identify detection antibodies and assemble trial assays for evaluation in the laboratory as follows: 1) Against standard set of dilutions of diluted virus stocks; 2) against individual and pools of known dilutions of virus stocks macerated with vector species; and 3) against laboratory infected vectors (evaluated separately by "gold standard" methods). End product are prototype assays with estimates of virus detection limits, accuracy, and maximum number of vectors per pool.

More specifically, the dengue dipstick already exists as a prototype that is sufficiently sensitive to DEN 2 and 4, but not to DEN 1 and 3. The next step in opitimizing the dengue dipstick would be to get a reliable source of dengue 1 and 3 infected mosquitoes (by intrathoracic injection of virus stocks into female Aedes aegypti at WRAIR and by oral feeding of a mixture of virus-RBCs-glucose to Aedes aegypti), retest the existing dipstick, and determine whether past failures were due to poor material or a need for technical readjustment of the dipstick. The dipstick would be readjusted by the industrial partner by increasing the concentration of DEN 1 and 3 detection antibodies or by increasing the concentration of virus in the mosquito triturate by filtering out solid material. If these adjustments do not increase sensitivity, then new monoclonal detection antibodies would be tested. These monoclonals would be created de novo by a subcontractor. Finally, if these new monoclonals were not sensitive enough, a general dengue detection antibody (monoclonal 4G2) could be added to the dipstick in order to deterimine whether any dengue type was present.

For the other viruses, attempts would be made to purchase the use of existing monoclonals, but new monoclonals would be made if necessary. Following assembly of trial dipsticks, a set of approximately 10 sticks would be tested against each of a set of serial dilutions of the stock virus in order to determine whether the sticks would be sufficiently sensitive compared to published viral titers known from mosquitoes. The sticks might need optimization in order to achieve sufficient sensitivity. Once the sticks appeared to be detecting the viruses in stock solutions at sufficient sensitivity, infected mosquitoes (both intrathoracically injected and orally fed) would be tested with RT-PCR as the gold standard for comparison. Source of infected mosquitoes would have to be coordinated with partner government or academic laboratories. These laboratories would have to colonize the representative vectors of the viruses (JE: Culex tritaeniorhynchus; Ross River: Ochlerotatus vigilax; Rift Valley: Aedes lineatopennis) and maintain sufficient biocontainment to handle live, infected mosquitoes. The goal of Phase I would be reached when sticks were available capable of detecting at least one-half log less virus than occurs in infected mosquitoes.

PHASE II: In this phase the contractor would perform research on whether the dipsticks would be a useful tool for evaluation of risk. The contractor from industry would assemble assays into kits with all necessary reagents and tools and distribute to at least two test centers (suggested sites: dengue: Armed Forces Research Institute for Medical Sciences and Walter Reed Army Institute of Research; Ross River virus: Australian Army Malaria Research Institute and US Army Medical Research Institute for Infectious Diseases; Rift Valley Fever virus: US Army Medical Research Unit-Kenya and US Army Medical Research Institute for Infectious Diseases; Japanese encephalitis virus: Armed Forces Research Institute for Medical Science and Walter Reed Army Institute of Research) for each virus. Test centers will receive written and personal training on the new assays and either performance of or shipment for "gold standard" method. Test centers will capture vectors from natural focus of the pathogen (at least 10 times the number of vectors expected to include one infected individual) or use laboratory infected mosquitoes, use the assay to test the vectors individually or in pools, and either perform the gold standard method or ship material so that the gold standard method can be performed at a central laboratory. Results of the evaluations will be analyzed, published in peer reviewed journals, and used as the basis for acceptance or rejection of the test. Protocols for the tests and the test results will be judged by the DoD Armed Forces Pest Management Board.

The contractor would evaluate the use of the dipsticks for risk evaluation by performing research on the incidence of the pathogen, abundance of the vector, vector competence, effects of weather on transmission potential, and dipstick results. The research would include determination of the best means of collecting each vector and the minimum number required for accurate determination that the pathogen is absent from the area (a key operational decision). The research would also determine algorithms of weather, human exposure to the vector, vector abundance, and dipstick results to produce specific probability of infection with an indication of likely error in the estimation.

PHASE III: The satisfactory tests will be produced and marketed, with application to the Armed Forces Pest Management Board for recommendation to assign a National Stock Number. Tests will be fielded to military field preventive medicine assets and promoted to USDA, CDC, and the Department of Homeland Defense for detection of introduction of the viruses in vectors.

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3) Extensive Multiple Test Center Evaluation of the VecTestTM Malaria Antigen Panel Assay. J. R. Ryan, K. Davé, K. M. Collins, L. Hochberg, J. Sattabongkot, R. F. Dunton, M. J. Bangs, C. M. Mbogo, R. D. Cooper, G. B. Schoeler, Y. Rubio, M. Magris, L. I. Romero, N. Padilla, I. A. Quakyi, R. G. Leke, C. F. Curtis, B. Evans, M. Walsey, P. Patterson, R. A. Wirtz, and A. S. T. Chan –Med Vet Entomol. Sept, 2002, 16 (3), 321-328.
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5) Sensitivity of the VecTestTM Antigen Assay for Eastern Equine Encephalitis and Western Equine Encephalitis viruses. Roger S. Nasci, Kristy L. Gottfried, Kristen L. Burkhalter, Jeffrey R. Ryan, Eva Emmerich and Kirti Davé – Accepted by Journal of Journal of American Mosquito Control Association
6) Comparison of Vero cell plaque assay, TaqMan reverse transcriptase RNA assay, and VecTest antigen assay for detection of West Nile virus in field-collected mosquitoes. Nasci RS, Gottfried K L, Burkhalter K L, Kulasekera V L, Lambert A J, Lanciotti RS, Ryan J R. – Accepted by J. Am. Mosq. Control Assoc.

KEYWORDS: Biowarfare defense, arbovirus, dengue, Japanese encephalitis, Ross River virus, Rift Valley fever virus, virus, mosquito, detection, risk assessment

A03-176 TITLE: A "Personal Blood Pack" to Improve the Availability of Red Cells for Transfusion during Contingency Operations

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Improve the Availability of Red Cells for Transfusion during Contingency Operations

DESCRIPTION: According to current doctrine, the only approved shipping container for the transport and storage of human Packed Red Blood Cells (PRBCs) ) in the battlefield is the “Collins Box” which keeps PRBCs at the required temperature (1-10° C) for approximately 24 hours under ideal environmental conditions. This box is a reusable cardboard and Styrofoam container, which can hold up to 30 PRBCs and weighs 44 pounds when loaded with 14 pounds of wet ice. The current weight and dimensions of the “Collins Box” makes it impossible for any soldier to carry it farther forward than the Forward Surgical Teams (FSTs). Recent military exercises have demonstrated the need for a lighter blood storage container that can be used during delayed evacuations when it may take over 12 hours to evacuate a wounded soldier. The transfusion of red cells far forward from the FSTs will enhance medical treatment and increase the survivability of wounded soldiers before evacuation takes place. A much lighter “Personal Blood Pack” that can carry one unit of PRBCs and keep them at the desired temperature for over 48 hours under extreme conditions is needed, as it would solve the weight and temperature control issues that we now face. Furthermore, since it should weigh only 2-3 pounds, any soldier can carry it during contingency operations. The “Personal Blood Pack” should be constructed with lightweight-super insulating material (i.e., vacuum insulated paneling, aerogel technology) capable of keeping PRBCs within the required temperatures under austere environments without the need for ice or batteries.

PHASE I: Identify insulation materials that will be capable of maintaining a unit of PRBCs within the required temperature range (1° to 10° C) for a minimum of 48 hrs. Identify a protective outside shell material for such an insulated container. Design and construct a container with these materials that will no more than double the weight of the unit and demonstrate temperature-maintaining efficiency under extreme external conditions (-20° to +40° C). Size must be such that the container can be attached to or placed inside a standard military-issue field pack

PHASE II: Demonstrate efficacy of the storage container in extending non-refrigerated red blood cell storage time by maintaining unit temperature within the prescribed range under extreme conditions. Perform or participate in clinical laboratory testing of units stored under field-simulated conditions.

PHASE III DUAL USE APPLICATIONS: Produce and support use of such a storage container during its introduction into clinical use. Addresses a market for provision of current and future (i.e. hemoglobin-based oxygen carriers, lyophilized plasma and RBCs, recombinant factor VIIa ) blood products that will need to be stored at 1-10° C.

REFERENCES:

1) TM 8-227-11 (Operational Procedures for the Armed Services Program Elements).
2) TM 8-227-12 (Armed Services Blood Program Joint Blood Program Handbook).
3) Food and Drug Administration, CFR #21 Section 640.


KEYWORDS: blood, red blood cells, blood products, storage container, mobile blood storage container.

A03-177 TITLE: <u>Development of a Field Portable Mosquito Monitoring System with Attractant</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: Adapt modern technology to incorporate observational monitoring software into a field portable mosquito monitoring system for common vectors of disease, such as adult Anopheles stephensi and Aedes aegypti, vectors of malaria and dengue respectively. REQUIREMENT: To increase the ratio of combat to support personnel and to preserve the health of combat personnel. Accurate surveillance of disease carrying mosquitoes provides risk assessment for some of the most important military infectious diseases including malaria, leishmaniasis, dengue, and West Nile virus. Current methods only approximately measure the risk, unless dangerous human-bait collections are performed. Better methods would reduce the number of vector control personnel required because their efforts could be targeted to the most problematic locations. Improved vector control would reduce the number of cases of disease among combat personnel. Development of a field exportable mosquito monitoring system to identify the true disease risk (from disease vectors) in an operational environment is therefore a high priority for the Department of Defense.

DESIRED CAPABILITY/CONCEPT OF THE FINAL PRODUCT: A portable device ready to use anywhere that electronically scores the number of disease carrying insects. We envisage a field portable, durable, light, remote mosquito monitoring system that incorporates observational software with more robust algorithms to handle lower contrast settings with higher background noise levels, into a small “data logger” type device used in conjunction with a miniature camera(s)/ imagery device to accurately record both visual and time duration data of mosquitoes landing on an artificial attractant surface. This system would be used in combination with an attractant-monitoring surface.

DESCRIPTION: The global prevalence of vector borne diseases such as dengue and malaria has grown dramatically in recent decades. In order to assess the effectiveness of any control effort directed against dengue mosquito vectors, it is vital to accurately and precisely sample the vector population. Such determinations must be made before, during, and after vector control in order to determine effectiveness of the control methods used. Accurate sampling provides the information necessary for operational entomologists to adjust their vector control efforts, if necessary. In addition, effective vector population sampling is necessary when attempting to predict disease outbreaks and determine when and where to apply control measures to prevent and suppress such outbreaks. The correlation between human biting/landing counts and the proportion of infected mosquitoes are key parameters in conducting effective field studies and subsequent control efforts in suppressing disease. The most common means employed and most representative of the local vector population responsible for disease transmission is the human biting/landing counts. Landing counts have the very strong advantage of converting to estimates of true risk (entomological inoculation rate). Without an accurate estimate of human biting, it is impossible to calculate risk from entomological data. Even though it is generally agreed among the scientific community that human bait collections are the most representative and reliable measure of vector populations responsible for disease transmission, the exposure it places on naïve collectors and the ethical sensitivity of using humans as bait. The difficulty of using military personnel for landing collections is that it is not only unpopular, but also exposes individuals to vector-borne pathogens, potential adverse skin reactions and exposure in tactically dangerous environments. The use of various traps have been used with varying degrees of effectiveness in sampling mosquito populations throughout the world; however, no trap exists today that correlates to human landing collections over a wide range of vector population levels, and provides the data necessary to calculate true risk. Several known factors of host-seeking behavior exhibited by mosquitoes include various visual cues, circadian rhythm, carbon dioxide, heat, moisture and host odors. Such factors in relation to human skin as an attractant have been investigated in addition to several sources of attractive stimuli from host odor such as sweat, blood, and chemical compounds. Although recently, commercial traps on the market have incorporated heat, carbon dioxide, and octenol, these traps are large, bulky, and require pressurized gas in their operation. Some of these traps also contain an electrical impulse grid that kill the mosquitoes and render them useless for identification. CDC light traps are the only adult mosquito monitoring devices provided to our Preventive Medicine personnel. These traps collect far fewer mosquitoes than human collectors and are ineffective in collecting the primary vector for dengue, Aedes aegypti. Therefore, a need exists to develop an alternative to human bait collections. The U.S. Army Medical Research and Material Command is developing a Dengue Vector Control System (DVCS) that incorporates integrated pest management principles with the objective of preventing dengue in our military and civilian forces. A very beneficial component to this system would be the inclusion of a mosquito monitoring system that can be correlated to human landing collections and has the ability to provide the data necessary in calculating true risk. This call for research will focus on the automated monitoring portion of the system.

PHASE I: Demonstrate the likelihood that an effective mosquito monitoring system for Aedes aegypti can be developed that meets the broad needs discussed in this topic. A system that incorporates our existing (or develop a new) observational software program that electronically scores not only the number of mosquitoes that land, but also the time duration mosquitoes remain on a monitoring surface and stores the data in a recording device/data logger with enough memory to record visual imagery and mosquito landing data obtained through the camera(s)/imagery device under variable light conditions and backgrounds. The "data logger"/device should be small in size and interface with observational software in the performance of recording imagery data at preprogrammed time intervals determined by the user and mosquito "landings" at one second or greater intervals for at least a 24 hour period. The software program should automatically analyze the transferred data and provide the number and time duration of each mosquito that landed on the attractant/monitoring surface based on user input settings. The camera(s)/imagery device should be small in size and have enough resolution to enable identification of a mosquito under variable light conditions and backgrounds which may be refined in Phase II. The user will perform the actual mosquito identification while viewing the collected data on a laptop or personal computer. The "data logger" should easily interface with a laptop computer for data transfer in a field environment. The packaged dimensions of the system should not exceed 2304 cubic inches and the entire packaged system itself should weigh 10 lbs (i.e., including battery power, support equipment, hand held computer device, crush proof packaging) or less. If the system is electrically powered, it must use rechargeable batteries or some form of extended power source and not require permanent, hard wired electricity. The system must be field durable, waterproof, and allow for operation in a remote environment, i.e., set-up and return to collect data all of which may be refined in PHASE II. Data transfer capability to a handheld personal computer is a PHASE II requirement. The researcher may refine and expand on our initial software or develop new software to meet our goals.

PHASE II: Develop and demonstrate an applicable and feasible prototype. Conduct testing to prove feasibility of

the system to monitor mosquitoes that land on an attractant/monitoring surface over time. Demonstrate that the data stored in the "data logger" is easily transferred to a laptop or hand held PC. The software program should automatically analyze the transferred data and provide the number and time duration of each mosquito that landed on the attractant/monitoring surface based on user input settings. Demonstrate that the visual imagery data collected under variable light conditions and background are detailed enough for mosquito species identification.
The researcher can expect that the WRAIR laboratory will support development of this system by providing disease free mosquitoes for use in our facility.

PHASE III / DUAL USE APPLICATIONS: The developed technology could be used by both military forces and by government ministries of health/vector control entities or commercial vector control operations in the United States and developing countries to accurately assess the presence of a disease vector and determine the true risk of disease when combined with an attractant (similar to human emanations) monitoring surface. Additionally, may be used to enhance trap monitoring of control efforts directed against the mosquito vectors of dengue.

COMMERCIAL APPLICATIONS (SPIN-OFF): Government ministries of health/vector control entities or commercial vector control operations in the United States or abroad could use this mosquito monitoring system in assessing the true risk of disease transmission. Developing countries use human landing/biting collections less frequently due to awareness of the exposure of the individual to potential disease infection. This device is different than existing commercial trapping/surveillance devices which only collect/attempt to collect the adult vector species in a given area. This mosquito monitoring system, when combined with an attractant similar to human emanations, would provide a needed device that would be commercially viable and replace the need for human landing/biting collections.

COMMERCIAL APPLICATIONS (SPIN-ON): The use of existing commercial observational software applications incorporated into a small, field deployable, mosquito monitoring system.

TECHNICAL RISK: There is a degree of technical risk involved in this project. Existing trapping/surveillance devices do not meet the requirements summarized in this proposal for a device that monitors by scoring and concurrently records visual imagery of target mosquitoes that land on an attractant/monitoring surface. The candidate contractor is expected to use innovation and in-house expertise to develop a prototype that meets the needs of the Department of Defense.

ACCESS TO GOVERNMENT FACILITIES AND SUPPLIES: The evaluation of an efficient mosquito monitoring system will require support from the Walter Reed Army Institute of Research in Silver Spring, Maryland for both laboratory and coordination for field testing of the device in dengue endemic locations, such as Thailand. The candidate contractor should coordinate with the COR for any required support prior to the submission of the proposal.

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KEYWORDS: Dengue, Dengue Hemorrhagic Fever, Entomological Inoculation Rate, Aedes aegypti, Aedes albopictus, Automated Data Logging, Remote Sensing, Mosquito Attractant

A03-178 TITLE: Noninvasive Treatment of Hemorrhagic Shock

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DSA, MRMC

OBJECTIVE: To develop a small, simple, lightweight noninvasive device to help sustain blood pressure after cardiovascular collapse from a battlefield injury until more definitive invasive treatment is available. This can be accomplished by decreasing intrathoracic pressure through a device that can be self-applied by the injured soldier or with assistance, if necessary.

DESCRIPTION: Research in the field of cardiopulmonary resuscitation has lead to the recent application of an inspiratory impedance threshold valve (ITV) to augment blood pressure during cardiovascular emergencies. ITV application has been tested in animals and patients during cardiac arrest and in animals during experimental hemorrhagic shock. In both settings, this simple approach results in a marked increase in blood pressure, thereby buying time until more definitive therapy (e.g., fluid resuscitation) becomes available. During the decompression phase of standard CPR, a small vacuum is created within the chest relative to the rest of the body every time the chest wall recoils back to its resting position (2). This draws venous blood into the right heart and air into the lungs. As such, ITV application can increase the vacuum within the thorax and double blood flow to the heart and brain. ITV application has increased survival rates in experimental animals and patients undergoing CPR. In a hemorrhagic shock model, application of an ITV resulted in restoration of normal blood pressures for >30 minutes in spontaneously breathing pigs, whereas pigs treated with a sham ITV remained in severe shock and died. However, ITV application has not been developed and tested in a human model of hemorrhage. Therefore, the purpose of this application is to develop and optimize features of a small, simple, lightweight ITV device and to prove the applicability of the ITV for treatment of combat-related shock.

PHASE I: This phase should result in a proof of concept workable device for application on humans. In order for the ITV to work well, it needs to be: a) effective and easy to use by the medic, b) seal well with the face of the patient, and c) enable the soldier to breathe through the ITV comfortably for a prolonged period of time. To optimize the value of the ITV for the treatment of hemorrhagic shock on the battlefield, it will be necessary to: a) determine a tolerable inspiratory resistance or cracking pressure for the ITV that will prove effective in increasing cardiac output and blood pressure in humans, b) assess the work of breathing through the ITV; and c) optimize the face mask to skin interface. It will therefore be necessary to measure key hemodynamic and physiological parameters in normal human subjects to determine if the ITV can increase stroke volume and blood pressure at breathing resistances that can be tolerated under normal baseline physiological conditions.

PHASE II: This phase should result in a device that can be used to maintain blood pressure in a human model of moderate to severe central hypovolemia and shock. The Human Physiology Laboratory at the US Army Institute of Surgical Research has developed such a human model using lower body negative pressure (LBNP). The human LBNP model will be used to establish proof of concept that the ITV enhances venous return by a simple thorax vacuum mechanism under conditions of central hypovolemia. This phase should also result in a practical device that can be used under conditions that will be found in the battlefield. Finally, several different versions of the ITV face mask combination will be assessed to develop a device that functions as intended with an excellent seal over the nose and mouth.

PHASE III COMMERCIALIZATIONn: This technology will have immediate battlefield application, and civilian pre-hospital application to be used by paramedics in the field or on ambulances for treatment of cardiac arrest and shock secondary to blood loss. This may particularly apply to rural or other delayed extraction situations where availability of fluid resuscitation and other life sustaining interventions may be delayed. In addition, an ITV device could provide potential military application to help pilots counteract severe gravitational forces, and civilian application for the treatment of excessive heat exposure and heat stroke.

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4) Convertino, V. A. Lower body negative pressure as a tool for research in aerospace physiology and military medicine. J. Gravitat. Physiol. 8(2):1-14, 2001.

KEYWORDS: shock. cardiac arrest, hemorrhage, impedance valve, intrathoracic pressure, blood loss

A03-179 TITLE: Non-Ceramic Small Arms Protective Inserts in Personnel Armor

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM-Soldier Systems

OBJECTIVE: Develop durable non-ceramic, low cost, lightweight personnel armor ballistic protective inserts for small arms protection.

DESCRIPTION: The primary ballistic protection offered against small arms rounds is based on ceramic with fiber-reinforced composite backing. Due to the nature of the materials used, these systems can be damaged or degraded during use. There are a number of current issues that make the development of this technology very desirable. Typically in current armor systems, non-ballistic materials are added to a ballistic insert to decrease the potential of field use damage, which adds parasitic weight to the system. Additionally, the current durability tests for such armors do not adequately simulate the in-service conditions nor is there an efficient non-destructive inspection methodology to assess the ballistic integrity of the armor systems during use in the field. The desired outcome of this effort is a durable, potentially lower cost and light weight ballistic protective insert system which provides the same or better ballistic protection against small arm ball rounds to include various 7.62 mm rounds as well as 5.56 mm rounds. These projectiles may contain a lead or steel core and can be defeated by current ceramic-based technology. The technology must offer a multiple hit capability (at least 3 defeats). The cost of developed technology should not exceed $450.00 in a finished product and should be able to withstand multiple drops at any location on the plate when dropped from a height of at least four feet on to a rigid surface (e.g., concrete, rocks). Approaches to this effort should be focused on advanced fiber-reinforced composites or advanced fibers and nanoparticle reinforced composites except materials which may cause environmental or personnel hazards. Technology is subject to export controls under current USML.

PHASE I: Research and develop one or more material systems which have potential to meet current Army's performance specification for dual-curved small arm protective inserts at 5.0 lb/ft2 or less. Develop material processing and designs to optimize the ballistic performance of the proposed material systems. Conduct ballistic testing on the proposed systems and multiple drop testing at any location on the plate when dropped from a height of at least four feet on to a rigid surface (e.g., concrete, rocks) to demonstrate the feasibility and practicality of the proposed material systems. Deliver a report documenting the research the development efforts along with a detailed description of the proposed material systems and their ballistic performance.

Proposed exit criteria – Technology Readiness Level (TRL) 3 – analytical and experimental critical function and proof of concept.

PHASE II: Develop the material systems and the processing technology identified in Phase I. Fabricate sufficient samples for extensive ballistic testing. The ballistic testing will include V0 and V50 tests with various small arm rounds, and the back face signatures as well. Deliver a report documenting the material system, material processing and ballistic performance.

Proposed exit criteria – TRL 5. Basic technological components are integrated to establish that the pieces will work together in a laboratory environment.

PHASE III DUAL USE APPLICATIONS: A new non-ceramic small arm protective insert would be applicable in both military and civilian armor arenas. The civilian law enforcement community would reap a substantial benefit from this effort.

Proposed exit criteria – TRL 6. Prototypes demonstrated in a relevant environment.

REFERENCES:
1) Michael Maffeo and Phil Cunniff, Composite Materials for Small Arms (Ball Round) Protective Armor, 32th International SAMPE Technical Conference, November 5-9, 2000, pp 768.
2) Phil Cunniff, Assessment of Small Arms (Ball Round) Body Armor Performance, Proceedings of 18th International Symposium on Ballistics, 15-19 November, 1999, San Antonio, TX.
3) MIL-STD 662F, 18 December 1997, Department of Defense Test Method Standard, V50 Ballistic Test for Armor.

KEYWORDS: Ballistic Protective Inserts, Personnel Armors, Non-ceramic materials, Composite Materials

A03-180 TITLE: Development of Stitchless Seaming Equipment

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To develop stitchless seaming system for Chemical Protective (CP) uniforms, rain suits, tentage, weapon covers, tarps or other environmentally protective end-items for manufacture using stitchless, nonsewn seams. The process shall eliminate use of sewing to assure that seams are leak-proof and offer the user establishment of safe inner environment and potential for automated assembly process. This proposal would eliminate the current process of sewing and seam heat-taping base fabric material, which is like sewing the end-item twice. The objective is to produce a seam structure with only one-pass through plus to use a seaming process that is compatible with different fabric compositions.

DESCRIPTION: New technologies such as laser welding that has been evaluated by the military. The process appears to weld seams extremely fast with different seam configurations and possesses 100 % seam efficiency; whereby the seam is as strong as the base material. This is critically important for high stress applications such as tentage, tarps, weapon covers and air-beams. Any stitchless seaming shall supply hermetically sealed seams for life of end-item. Further research is needed to develop the various aspects of the process and interaction between materials and how end-item pattern pieces can seamed together and be fed into an activation zone in order to produce either straight or three-dimensional seams. Previous research using ultrasonics, extruded adhesive seaming, seam taping and heat welding processes have been a technical challenge and disappointing in not being able to bond dissimilar materials together. Plus such technologies possess low seam strengths and are not durable.

PHASE I: Phase I will consist of researching into development of prototype stitchless equipment and conducting an application study into capabilities of seaming textiles with a stitchless process with an array of military materials and seam types. Materials include lightweight Nylon Taslan fabric with breathable film backing, Vinyl coated polyester tentage/tarp fabric, lightweight charcoal activated scrim fabric for CP liner, nylon/cotton water-repellent treated outer CP fabric, breathable coated nylon rain-suit fabric, Kevlar ballistic fabric, lightweight nylon rip-stop parachute fabric, urethane coated air-beam/ water-proof bag fabric and others. All textile fabric specs and/or fabric samples shall be provided as Government Furnished Materials (GFM). Typical seam constructions used for Military end-items would be ASTM seam types FSf, LSa, SSa, LSb, LSp and others. A goal is to maximize seam constructions, seam cross-wise and peel strength using the proposed stitchless technology as the primary trigger, along with a plan to construct a typical CP Uniform with it's numerous pattern pieces along with typical closures (zippers, hook and loop, etc) and small parts (pockets, plackets, cuffs, collar, etc).

PHASE II: Phase II would consist of developing Phase I plan into an actual stitchless seaming machine with thought of incorporating means of reducing labor, increasing automation and maximizing safety aspects of machine. Included shall be off-the-arm considerations for construction of typical trouser leg seams, jacket arm sleeve seams, etc., along with three-dimensional seamed constructions such as crotch seaming. underarm seams, seat seams, etc. Completed stitchless seaming machine shall demonstrate the means to fabricate a typical CP Uniform along with all closures and small parts. Typical sewn bartacks and internal sewn seaming (seaming not externally shown) may be used in final construction. Unit shall demonstrate use of maximized automation processes for pattern piece handling.

PHASE III: DUAL USE COMMERCIALIZATION: This new process would impact commercial market in numerous ways. End-items for outdoor market would offer waterproof seams, nuclear, toxic waste and land fill industry would have nuclear/chemically protective seams, leak-proof ground protection, composite industry for potential airplane and glider production, commercial tentage, tarps, ground covers, pool liners etc. Large scale manufacturing of proposed stitchless seaming equipment with automated processes, would counter American demise of textile and composite manufacturing.

REFERENCES: American Society For Testing And Materials (ASTM) 'Standard Practice for Stitches and Seams' D-6193.

KEYWORDS: Laser Welding, Seams, Stitchless, Environmentally protective.

A03-181 TITLE: Self-Decontaminating Barrier Material Incorporating Catalytically Reactive Membranes for Individual and Collective Protection on a Chemically/Biologically Contaminated Battlefield

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PM- NBC Defense Systems

OBJECTIVE: Explore thin, lightweight, durable, flexible, self-decontaminating, flame resistant, and low solar loading barrier materials impermeable to liquid, vapor and aerosol chemicals and microorganisms. These lightweight composite barrier materials will be based on the employment of an ultra-thin catalytically reactive barrier. During Phase I a proof of concept will be demonstrated based on the needs/requirements for a collective protection barrier fabric, however individual protection requirements/needs will need to be addressed during Phase II.

DESCRIPTION: There is a deficiency in the U.S. Army for a CB resistant material, which is lightweight, flexible, decontaminable and affordable. Only two materials have been approved for procurement for CB resistant shelters. One is a disposable polyethylene/saran material, which is inexpensive and lightweight, however lacks UV and flame resistance, is not decontaminable and only provides limited protection (72 hours). The second is a high performance Kevlarâ/Teflonâ material, which is currently being used for the Chemical Biological Protective Shelter (CBPS) [Mil-Spec LP/P DES 1-94a, 20 Jun 1995]. This multi-laminate material provides excellent chemical and biological protection while being flame and UV resistant. However this material is expensive, bulky, semi-rigid and labor intensive to produce. The availability for a chemical and biological resistant material, which is affordable and can be reusable after a chemical and biological attack, will greatly enhance the effectiveness of the future soldier.

There is currently a Defense Technology Objective (DTO) to develop a CB protective electron-spun air-permeable membrane for individual protection suits. The proposed topic will develop an impermeable membrane to liquid, vapor and aerosol agents with the ability to self-decontaminate. This technology will have dual applications to both collective protection shelters as well as certain classes of individual protection suits.

PHASE I: Phase I will be a proof of concept, which will demonstrate the technical soundness for a self-decontaminating barrier material. This concept will focus on the needs/requirements of a collective protection barrier fabric. The following tasks will be performed: (1) Investigate lightweight composite barrier fabric which is based on the employment of an ultra-thin catalytically reactive1,2,3,4 barrier material. The investigation will include elastomers and thermoplastics. (5) (2) Identify materials/chemical structures that have physical properties compatible to the strenuous activities that a shelter would experience. (3) Identify factors that would influence the diffusion of chemicals and migration of biological species into and through materials to better develop barrier materials. (6) Molecular permeation model of CB agents through selected polymers will be established using selected computer simulation. (4) Based on tasks 1-3, produce and demonstrate non-optimized self-decontaminating catalytically reactive materials and verify potential through simulant testing.

PHASE II: At least two materials (best candidate materials selected in Phase I) will be selected, optimized, assembled into a composite material/fabric system, and tested for a variety of industrial chemicals and CB agents. The ability for the fabric to self-decontaminate via a catalytically reactive membrane will be quantified. The composite materials will be produced and expanded to include the requirements for both collective and individual chemical/biological and environmental protection. These composite material/fabric systems will have different composite structures to address the requirement variance. Novel, low-cost manufacturing techniques to fabricate composite barrier fabric systems will also be investigated.

PHASE III: No material is currently in existence that can be proven to be decontaminated in a combat field environment and be safe for reuse after vapor contamination. The proposed material will allow Joint Service Explosive Ordnance Disposal (EOD), Technical Escort Units (TEU), Chemical Activities, Defense Preparedness, Joint Transportable Collective Protection System (JTCOPS)-Block 2, and Future Medical Shelter Systems to field, decontaminate and reuse their individual protective equipment/shelters. This area will also open a new realm of reactive materials for use in civilian and military markets, i.e., formerly utilized defense sites (FUNDS) cleanup operations, civilian emergency responses to chemical incidents (terrorist, or chemical activity/accidental emissions).

REFERENCES:

1. Y. Jiang, S. Decker, C. Mohs, and K. Klabunde, “Catalytic Solid State Reactions on the Surface of Nanoscale Metal Oxide Particles” Journal of Catalysis, 180, 24-35, 1998.
2. Sandia National Laboratories, “Sandia decontamination foam may be tomorrow's best first response in a chem-bio attack.” March 1, 1999 News Release. Also: http://www.sandia.gov/SandiaDecon/factsheets/tests_jan2002.pdf
3. T. M. Tesfai, V. N. Sheinker, and M. B. Mitchell, “Decomposition of Dimethyl Methyl phosphonate (DMMP) on Alumina-Supported Iron Oxide” J. Phys. Chem. 102, 7299-7302, 1998.
4. M. B. Mitchell, V. N. Sheinker and E. A. Mintz, “Adsorption and Decomposition of Dimethyl methyl Phosphonate on Metal Oxides.”
5. R. Xu, J. L. Mead, S. A. Orroth, R. G. Stacer, and Q. T. Truong, “Barrier Properties of Thermoplastic Elastomer Films,” Peered Reviewed, Journal of Rubber Chemistry and Technology, Volume 74, Issue 4, Sep-Oct 01.
6. Andrei A. Gusev and Hans Rudolf Lusti, “Rational Design of Nanocomposites for Barrier Applications”, Adv. Mater. 2001, 13, 1641-1643.

KEYWORDS: Textile, Membrane, Perm-selective, Chemical, Biological, Protection, Barrier, Self-decontaminating, catalytically-reactive.

A03-182 TITLE: Individual Cooling Element (ICE) for Improved Warfighter Hydration

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM-Soldier Systems

OBJECTIVE: To develop a low cost, lightweight and safe method for chilling beverages that can be integrated into Objective Force Warrior through the Future Hydration System.

DESCRIPTION: The Armed Forces have a need for cold beverages in the field. Hot climates such as the desert and jungle require the soldier to drink over a gallon of water a day (1, 2). Studies have shown that in arid zones when the water is warm, soldiers actually drink less (5, 6, 7, 8). This can lead to dehydration resulting in muscle fatigue, heat stroke or death. Ice can be used to keep beverages cold but getting ice to soldiers is difficult from a logistical standpoint; freezers are large, heavy and usually used to store food, not ice. Ice melts quickly in arid environments, making it hard to transport. Water trailer mounted chillers exist but the current version has shown to be too heavy for the trailer, causing stress fractures in the trailer itself and its use is now intermittent and rare. Even cold water becomes warm, as units disperse and time passes, water in canteens and water-bladders becomes warm and unpalatable and without iodine tablets, must be discarded when water temperatures reach 92°F due to high bacteria counts (3,4). A portable, non-electric, reusable beverage chiller would insure that every soldier has access to a cool beverage that is both palatable and safe. Accordingly, innovative technology is required that will provide a nonelectric, compact device for the warfighter to chill beverages while operating in the field. The Individual Cooling Element (ICE) can be single-use or reusable. One example of an acceptable single-use approach would be a vacuum-sealed pouch containing sorption media, a membrane and a breakable refrigerant capsule. The operator breaks open the capsule by squeezing the pouch and the vacuum causes the refrigerant to vaporize and collect in the adsorption media, thus cooling the surrounding beverage. A reusable approach might be better. An example would again involve a sorption media and a vacuum but it would be a rugged device capable of being stored with a partial vacuum. After the cooling is accomplished, heat is added to the system using a squad stove or a field kitchen oven. This would drive the refrigerant out of the sorption media, back across the membrane and into a sealable chamber. It is desired that the refrigerant be water, but other nontoxic and environmentally safe refrigerants will be considered. Surface modified carbon, zeolites and complex-compounds can be used as sorption media. The device must be capable of chilling 32 ounces of water by 20°F in less than 10 minutes. The device must weigh no more than 4 ounces (2 ounces desired). All components must be safe for incidental contact with water.
This technology directly supports all three Force Health Protection pillars outlined in Future Operating Capabilities FOC-11-03 (Global Health and Fitness), and FOC-11-06 (Casualty Prevention) by improving hydration and reducing heat-related injuries.

PHASE I: Phase I will consist of research of refrigerant, sorption, and regeneration materials and methods. The research shall include potential configurations and interfaces with canteens, cups and bladders. The strengths and weaknesses of each alternative shall be detailed in terms of operational effectiveness, weight, size, cost, health hazards, safety, ruggedness, shelf life, and stability. From this data, trade off studies will be performed to determine what characteristics are preferred for ICE. A proof-of-principle prototype will be designed and demonstrated for the best alternative(s). Phase I shall include a demonstration of the ability to cool 16 ounces of water by 20°F in less than 10 minutes, meet the 4 ounce weight requirement or show how the weight requirement can be met.

PHASE II: Phase II would consist of refining the design and building prototypes for delivery that will meet performance and weight requirements (50 if single use, 10 if reusable). Technology will be scaled to successfully chill a 2-liter water bladder as used in the Future Hydration System. Address producibility, manufacturability, and ruggedness and suitability for military use. Provide a preliminary manufacturing plan and a comprehensive investigation for compliance to all safety and health regulations with respect to the operation, transportation, storage, and disposal of the hydrogen capture or utilization system.

PHASE III DUAL USE COMMERCIALIZATION: The beverage industry has shown interest in offering a self cooled product and there are many patents and prototypes to choose from but high cost and bulk remain as barriers to a successful product. This program will solve those problems through innovation that will lead to a low cost, low bulk technology.

REFERENCES:
1) Army Field Manual 10-52; Ch 3, Water Supply Planning.
2) Army Field Manual 21-76; Ch 13, Desert Survival.
3) Draft ORD for a Nuclear, Biological, Chemical Environment Personal Hydration System (NEPHS), Potential ACAT IV, Paragraph 4.a.3.h, (copies available through Ms. Kathy Swift 508-233-5451).
4) Army Newsletter 90-7 Winning in the Desert; Ch 4, Environmental Effects on Personnel; Lyle, James, Sept 1997.
5) Palatability of Drinking Water: Effects on Voluntary Dehydration; USARIEM, Szlyk, Patricia C.; Sils, Ingrid V.; Francesconi, Ralph P.; Hubbard, Roger W.; Armstrong, Lawrence E., March 1998.
6) Patterns of Human Drinking: Effects of Exercise, Water Temperature and Food Consumption; USARIEM, Szlyk, Patricia C.; Sils, Ingrid V.; Francesconi, Ralph P.; Hubbard, Roger W., Feb 1989.
7) Engell D, and Hirsch E., 1991, Environmental and Sensory Modulation of Fluid Intake in Humans, In Booth D, & Ramsay D (eds.), Thirst: Physiological & Psychological Aspects, London: Springer-Verlag, PP 382-390.
8) Sandlick B L, Engell D B, Maller O, 1984, Perception of Drinking Water Temperature and Effects for Humans after Exercise. Physiology and Behavior 32:851-855.

KEYWORDS: Beverage chiller, cooler, heat pump, surface modified carbon, adsorption, zeolite, refrigeration

A03-183 TITLE: Development of Silent Hook and Loop Closure System

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop silent hook and loop (touch fastener) closure system for use on combat based uniforms that require stealth attributes. Also closure system shall be resistant to mud, silent in extreme cold, be autoclavable (steam resistant), resistant to lint pickup in laundering, edge peeling, be lighter weight, thinner, more flexible without loss of holding strength and offer characteristics that counter such detrimental qualities in current closure system.

DESCRIPTION: Current hook and loop closure system has numerous deficiencies that counters combat effectiveness by users in the field, with the most serious defect identified as noise when being disengaged. The element of extreme cold enhances the noise level, thus renders any such uniform using hook and loop useless in terms of offering stealth characteristics. However, despite the noise characteristic, hook and loop closure systems are the most popular of all the closure systems due to their ease of use. Hook and loop tapes are commercially available from numerous companies either in the form of woven, knit or extruded polymer. Past studies on the subject have concluded that the source of noise is hook tape. As the tapes are being disengaged the hooks vibrate and the noise resounds off of the backing tape in a process known as ‘resonance’. This was proven in a previous proprietary study when a large commercial supplier constructed a nonbacked hook tape and was shown to be noiseless when disengaged in mid-air. However, when sewn to an end-item textile unit, the noise returned. The textile backing on the end-item served as a backboard.

PHASE I: Phase I will consist of researching into development of prototype utilizing new hook design or alternate means to create engagement and silent disengagement without sacrifice to typical minimum shear strength of 5.0 pounds/inch as tested per A-A-55126, ‘Hook and Loop Closure Tape’ requirements. Noise levels shall be a minimum of 85% reduced compared to typical woven hook and loop structure meeting A-A-55126 requirements at 0 degrees F. Also, hook and loop structure shall maintain 90% of shear strength properties after autoclaving process for 1 hour, resist lint pickup when home laundered and tumble dried 3 times on hot cycle with 4 pounds cotton based load, also tape shall not edge peel, be thinner and more flexible with no needlecutting than current closure system.

PHASE II: Phase II would consist of developing prototypes of hook and loop closure system for wear testing upon multi-service cold weather/chemical protective clothing applications, to be determined.

PHASE III DUAL USE COMMERCIALIZATION: Silent hook and loop would be beneficial for commercial application for children's wear, outdoor hunting gear, commercial tentage, sleeping bags, dress shirt and other applications that require stealth. Also, additional features under Phase I would enhance the closure system for general commercial use.

REFERENCES:
1) 10 A-A-55126, 'Hook and Loop Fastener Tape', Commercial Item Description. (available from Maria Scott, (508) 233-4185, email: maria.scott@natick.army.mil)

KEYWORDS: Hook and loop, closure system, silent, fastener

A03-184 TITLE: Modular Parachute Concepts

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM-Force Sustainment Systems

OBJECTIVE: To develop and demonstrate modular parachute concepts and advanced textile connectivity concepts for rapid rigging and rapid de-rigging/recovery of large parachute systems and potentially for rapid conversion of parachute systems allowing for a larger range of payload weights and applications.

DESCRIPTION: The US Army envisions the development and fielding of large parafoil systems (See references) for use in delivery of large cargo and vehicles. These systems consist of multiple types of fabrics, webbings and cordage and require specialized rigging facilities and a team of recovery personnel. This represents a major technical hurdle to the ultimate fielding of precision airdrop systems that are too large and heavy for field recovery for reuse. The objective of this work is to develop modular parachute concepts through the use of new and novel fabric-to-fabric, cordage-to-fabric, and cordage-to-cordage connections and attachment concepts/technologies to allow for rapid rigging/assembly of a parachute with potential of system modularity. Examples may include systems that allow for construction of parafoils from individual cells that are easily, rapidly and securely fastened prior to final packing/rigging to "size the airdrop system" for the desire application and assist in personnel handling of the system. The potential to partially rig/fold each cell prior to assembly could be considered. On the recovery side, each individual cell would be rapidly removable and easy to handle for a single soldier. A similar example for round parachutes could consist of removable gores and/or panels to allow for tailoring the canopies to the payload size/weight being dropped and allowing for more flexibility in controlling the rate of decent of Army payloads that can range significantly. Quick disconnect-able cordage to parachute systems are desired and fabric to fabric connectivity solutions are sought allowing for a single soldier to move large systems and configure systems easily and possibly rig large systems in smaller confined spaces than currently required. Advanced Velcro and/or zipper type systems are potential solutions but concepts must be capable of withstanding the large opening shocks associated with airdrop systems and be easily installed/removed and completely re-usable with minimal maintenance. Multiple reuses are critical. The capability must also be applicable for rapid repairs on damaged systems and not require any specific hardware to make the modifications/repairs. As an example, cross canopies could be made from a collection of square sections that are connected for a given application and could be scalable by symmetrically adding more building blocks as needed.

PHASE I: In this phase, new modular parachute concepts and innovative technologies/methodologies to fabricate parafoils should be developed with the focus on connectivity technologies and maximum modularity (i.e., range of airdrop payload capabilities) with all systems usable and modifiable by a single soldier with minimal/no tools required. In addition to the parafoils, other canopy varieties (round/cross type systems) are desired. Prototype system design and fabrication are 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 of smaller scaled (i.e. up to 2200 lb payload) systems. Documented ground tests of the connections/systems ability to withstand anticipated opening shock loads should be conducted in advance of any flight tests. Modular parachute designs of common sized canopies should be considered but new parachute designs potentially more practical for the modularity concept will be considered.

PHASE II: Demonstrate the concept via design and construction of a range of cargo size parachutes. 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. Demonstrations of at least one system that can range from a minimum payload weight up to a 5000lbs system should be proposed. A detailed cost analysis that includes rigging time and re-configurations should be conducted. The government will entertain a large series of drop tests of mature technologies to explore the reusability and repeatability of such systems.

PHASE III DUAL USE APPLICATIONS: This technology could be applicable to all types of fabric constructions such as large maintenance tents. Systems could be used by the Coast Guard, law enforcement/rescue, ski patrols, border patrols, drug intervention forces, forest fire fighting support and for humanitarian relief operations. These systems would allow for less storage and inventory of more traditional parachutes potentially saving all organizations storage and inventory related costs.

REFERENCES:
This topic addresses needs outlined in TRADOC Pam 525-66, Future Operational Capabilities (FOCs), http://www.tradoc.army.mil/tpubs/pams/52566frm.htm:
(1) QM 99-001 & SF 98-605. Aerial Delivery/Distribution.
(2) CSS 98-001. Battlefield Distribution.
(3) CSS 98-002. Velocity Management.
(4) Art 4.0-Perform CSS and Sustainment.
(5) IN 97-300. Mobility-Tactical Infantry Mobility.
(6) IN 97-301. Mobility-Tactical Infantry Deployability.
(7) IN 97-321. Mobility-Soldier's Load.
(8) TC 98-002. Force Projection Operations.
(9) TC 98-004. Rapid Supply/Resupply of Early Entry Forces.
(10) DBS 97-030. Mobility-Tactical Dismounted Mobility.

KEYWORDS: textiles, airdrop, tents, parachutes, cargo parachute systems, and autonomous airdrop system.

A03-185 TITLE: Micro-Atomizing Logistic-Fuel Delivery System

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM-Soldier Systems

OBJECTIVE: A system that remotely delivers a micro-atomized/vaporized fuel-air mixture suitable for flame or catalytic combustion in ration or water heating devices.

DESCRIPTION: In military field situations, the most logistically sensible way to provide heat is through fuel combustion. However, clean and efficient burning of diesel and JP8 requires complex electrically-powered equipment because these fuels are broad-cut, very viscous, and have low volatility. Vigorous mixing with air, and pressures of 1400-7000 kPa (200-1000 psi) and above must be employed to generate a mist of particles sized 40-80 microns traveling at 100 m/s; otherwise, nozzles and passageways will experience gumming due to destructive decomposition (cracking) and distillate separation. In high-output (150 kW) applications, such as entire kitchens, the power requirement and cost can be justified. The situation is different for personal body-, food-, and water-heaters of only 50-500 W (170-1700 BTU/hr) where compactness and lightweight are desired. Simple methods, such as wicks and camp-stove vaporizers, are not suitable -- and do not apply to catalytic combustion. Fortunately, emerging and concept technologies show promise for enhancing vaporization of heavy fuels with minimal power input through pre-combustion atomization and strategic mixing with air. Possibilities include, but are not limited to:

microchannel-boiling, electrostatic dispersion, thin-film techniques, cavitation foaming, nanoturbine ejection, ultrasonic misting, or capillary pumping. Power is conserved by limiting pre-atomized pressures to below 200 kPa (0-30 psi), and reducing air velocity. Particle velocity may drop into the 10 m/s range, so size may need to be reduced to below 6 microns. As a second stage in the process, post-atomization mixing chamber characteristics can serve to inhibit wall collisions and agglomeration.

PHASE I: Identify the best configuration for a system that will atomize/vaporize heavy logistical fuels and mix the product with air, delivering it through a hose without condensation or dripping, so it is a product ready to be combusted, either via flame or catalytic methods. The concept should be scalable and ultimately capable of variable feed rates. The fuel should not require additives or other pretreatment. Any practical device will use no electricity, or little enough that a single battery-pack will last 72 hours or 300 periods of 15-minute operation. The battery required must be consistent with the application -- for example, personal portable devices might be limited to four AA's, while heat-driven refrigerators could accommodate something much larger. A proof-of-principle prototype will be constructed to demonstrate effective operation. Reporting will include identification of strategies and areas of improvement such that a Phase II product will meet military requirements for operation and safety.

PHASE II: Build five refined prototypes that can be used for limited field testing and demonstration/display. The product will be highly durable and capable of a variable feed rate. It is hoped the size of a device for delivering 300 W's (1000 BTU/hr) will be smaller than a deck of cards (not including a 12" delivery hose) with a corresponding economy of power. Strict attention to MANPRINT and safety factors will be observed.

PHASE III DUAL USE APPLICATIONS: Military systems requiring low to moderate heat input range in size from 50 W (170 BTU/hr) personal warming vests to the 16 kW burners used in portable kitchens kits. The micro-atomizer device would most immediately be applied toward open-flame and catalytic pocket-stoves and personal heater devices, enjoying significant popularity in civilian camping, hiking, and winter sports. The next most useful application is air heaters, water heaters, and heat-driven refrigeration. Currently, propane is used in RVs since it is an easily handled fuel, and it burns cleaner than diesel using existing technology; however, it's volatility does result in the occasional maelstrom -- heavier fuels would be much safer. Micro-atomizer technology would be similarly useful in cab, engine-block, and water heaters used in mobile situations or where independent operation is necessary. Espar produces popular diesel-fired versions of this equipment, and it is anticipated atomizer technology would render their devices more efficient and cleaner burning without sacrificing performance.

REFERENCES:
1) Electrostatic Atomization - Experiment, Theory, and Industrial Applications - http://pst.pppl.gov/tt/electrostatic_atomization.html
2) A Guide to Assist in Evaluating Liquid Fuel Flames - http://www.coen.com/i_html/white_liquidfuel.html
3) Burning Residual Fuel Oil -http://energyconcepts.tripod.com/energyconcepts/heavy_oil.htm

KEYWORDS: combustion, atomization, fuel, diesel, JP8, pocket-stove, cooking, heating

A03-186 TITLE: <u>Hydrogen Capture or Utilization in Mg/Fe Based Chemical Heaters</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Joint Project Director, Combat Feeding Program

OBJECTIVE: To research alternatives and develop a low cost lightweight safe method for suppressing, capturing or utilizing the hydrogen released by Mg5at/Fe chemical heaters used for heating individual and group rations.

DESCRIPTION: DoD uses a lightweight, low cost, easy-to-use chemical heater called the Flameless Ration Heater (FRH) to heat the standard operation ration, the Meal, Ready-to-Eat (MRE). An FRH is packed with every MRE and over 25 million are procured and used each year. The FRH weighs ½ ounce and raises the temperature of the 8-ounce MRE entrée by 100°F in 10 minutes. Unfortunately, upon activation the FRH releases 8 liters of hydrogen.

While this presents no operational problems, there have been storage and disposal issues, primarily due to generalized regulations and the unique nature of this item. After 10 years of research, no non-hydrogen producing chemical heating systems have been found that match the cost, safety, and performance of the FRH. While research continues for an FRH replacement, the problems associated with hydrogen are manageable. However, a larger chemical heater is needed for a group ration called the Remote Unit Self Heated Meal (RUSHM). The RUSHM weighs 26 pounds and requires approximately 20 ounces of heater material that will produce 11.3 cubic feet of hydrogen. In a confined space, there is a high probability that hydrogen's Lower Explosive Limit (4%) could easily be reached. Therefore, an inline method is required to capture the hydrogen and prevent release to the atmosphere. It is preferred that the caloric power (320 BTU/cubic foot) of the hydrogen be used to heat the food for maximum efficiency. It is also desired that the solution be scalable down to the FRH. Minimum weight, size, cost, and complexity are desired characteristics, in order of importance. In addition, the solution must be disposable and production cost should not exceed the cost of the RUSHM heaters (~$10). All materials must be Generally Recognized as Safe for incidental food contact or must be separated from the food to prevent any possible food contact due to unintentional opening or rough handling (shock or vibration). The materials shall also be safe for operation, transportation, storage, and disposal (activated or not).

PHASE I: Phase I will consist of research of hydrogen storage, scavenging, scrubbing, sorption, and suppression technology such as activated carbon, zeolites, metal hydrides, slurries, etc. and/or research of oxidation catalysis (note: reaction byproducts are only hydrogen and water vapor). The research shall include potential configurations and interfaces with the chemical heater and RUSHM. The strengths and weaknesses of each alternative shall be detailed in terms of weight, size, cost, health hazards, safety, ruggedness, shelf life, and stability. From this data, trade off studies will be performed to determine what characteristics are preferred for the RUSHM. A proof-of-principle prototype will be designed and demonstrated for the best alternative(s).

PHASE II: Phase II would consist of developing full-scale prototypes that will be integrated in the RUSHM. If applicable, FRH scale prototypes will also be developed. Development will include a comprehensive investigation for compliance to all safety and health regulations with respect to the operation, transportation, storage, and disposal of the hydrogen capture or utilization system.

PHASE III DUAL USE COMMERCIALIZATION: Calcium oxide is currently widely used as heating element for a range of commercial food and beverage products. It is very inexpensive, but it is bulky and can weigh 10 times as much as the Mg/Fe heater used by DoD (i.e., food to heater ratio of 2:1 vs. 16:1). It also can get dangerously hot (over 300C vs. 100C). The real and perceived hazards of hydrogen have held back the commercialization of the Mg/Fe heater. Once the hydrogen problem is solved, these heaters will have wide spread application for commuter meals, self-heated beverages, mobile catering and buffet tables (especially where fire codes do not permit open flames).

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KEYWORDS: chemical heater, magnesium, hydrogen, adsorption, catalyst, oxidation

A03-187 TITLE: Medical Textiles

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: PM- Soldier Systems

OBJECTIVE: Incorporate advanced bio-textile technologies to provide advanced skin and/or wound infection barrier to the warfighter in combat operations.

DESCRIPTION: The biotechnology industry continues to research ways to develop compounds that can be added to textile substrates that will provide healing medication to wounds and/or prevent infections from microorganisms to improve the quality of health worldwide.

This effort will explore research efforts in bio-textiles that will provide advanced clothing items and/or wound dressings that prevent infections from microorganisms for application to the warfighter in combat operations. The use of in situ infection preventing treatments in multifunctional wound dressings can provide our warfighter with a degree of medical treatment until further medical assistance becomes available. Technologies that need to be explored in textile substrates are: clot-enhancing treatments and enhanced anti-microbial/antibiotic materials for healing and preventing of infection of soft tissue.

Several academic institutes are performing studies in the areas of anti-microbial treatments that will bacteria on contact without exacerbating the resistance of bacteria to antibiotics. Recent studies performed by personnel from Massachusetts Institute of Technology have shown that covalent attachment of N-alkylated poly(4-vinyl-pyridine) groups or (N-alkyl PVP groups) to glass surfaces provided the glass surface with protection (lethal) to both gram-negative and gram-positive bacteria. The application of carbohydrate-based materials on cotton, silk, rayon and wool by Queens College, NY, also has shown promise in providing durable antibacterial properties. A new class of rechargeable anti-microbial compounds, halogen containing compounds, N-halamines, has recently been developed which claim to "acquire their anti-microbial qualities by virtue of their covalent binding capacity for the halogens, chlorine and bromine."

A great deal of work is being done to develop bio-textile materials that are infectious-resistant for use on prosthetic arterial grafts made with antibiotic containing polyester. These antibiotics are attached to the polyester fiber by linking very small amounts of antibiotics to the dye molecule during the conventional disperse thermosolling dyeing process or using polyurethane coatings as a carrier medium.

Microbiologic studies have shown that bio-textiles containing antibiotics (ciprofloxacin) were highly effective against infections containing bacteria Staphylococcus aureus (S. aureus) and Staphylococcus epidermidis (S. epidermidis) both in vitro and in vivo (directly contaminated models). Cotton/polyester fabric treated with antimicrobial compounds was very effective in killing a variety of bacteria, i.e., E. Coli, S. aureus, Salmonella, etc., and fungus.

Studies have shown that the continuous use of antibiotics can lead to the development of antibiotic resistant strains of organisms. Therefore, the use of textile containing antibiotics would be limited to use only on wound dressings or other items where its use is limited to special unique situations.

The primary goal of this research effort will research available biotechnologies and apply them to unique textile items to provide the individual soldier with an advanced biomaterial that protects the skin and wounds from microorganism contamination in the battle field environment. Providing the individual soldier with this added protection will diminish the chance of wound infections when medical attention is noot imminent. Clot-enhancing bio materials and other infectious preventing chemical compounds can be incorporated into textile materials thru the dyeing process, topical treatment or microencapsulating the compounds for on time release. The microcapsules would break open and release the active compunds when sufficient pressure is applied.

PHASE I: (1) Evaluate innovative advanced bio-textile technologies. (2) Treat textile substrates with anti-microbial compounds and other infection prevention compounds. (3) Perform analytical tests such as American Association of Textile Chemists and Colorists (AATCC) Test Method 100 "Antibacterial Finishes on Textile Materials: Assessment of" to assess effectivess of the antimicrobial.

PHASE II: Develop prototype textile items (i.e., wound dressings, undergarments, socks, battledress uniforms) containing antimicrobial treatments as appropriate and perform field testing. In coordination with U.S. Army Institute of Surgical Research perform in vitro testing to evaluate the effectiveness and protection of the antimicrobial barrier.

PHASE III DUAL USE COMMERCIALIZATION: Medical textiles with the above desired characteristics can be used as first-aid products for households, camping, and mountain climbing. Could also be used as first aid in peacekeeping, terrorist’s disasters and natural disasters such as hurricanes, earthquakes and other similar high contamination and injury situations.

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KEYWORDS: bio-textile, anti-microbial, neuroprotectant drugs, antibiotic, biomedical

A03-188 TITLE: Height Sensors and Velocity Sensors

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM- Force Sustainment Systems

OBJECTIVE: The primary objective is to develop/integrate a suite of height and velocity sensors to meet the needs of cargo and precision airdrop systems. The desired sensors and integrated suite must be lightweight, low cost and operate reliably and consistently while sustaining the loads, shocks and environmental conditions associated with airdrop operations and testing. Parachute opening shocks of 5-10 Gs are typical, as is impact velocity of 30 ft/s for 5,000 lb to 42,000 lb platform payloads and an impact velocity of up to 90 ft/s for 2,200-pound Container Delivery System payloads. Environmental conditions include temperatures ranges from –70 F at drop altitude to +160 F on the drop zone in direct sun. Moisture resistance is desired; moisture proof would be a plus. The sensors need to accurately identify the ground with a one foot tolerance at 30 to 50 feet (higher is better) above the ground under battlefield conditions which includes smoke, rain, snow, trees, grass and other vegetation, etc. A variety of technologies including radar, sonar and laser have been examined in the past, but each technology had some difficulty meeting all of the requirements. The system must accurately sense the ground through a variety of vegetation scenarios; this is an area where past systems encountered difficulties in meeting the requirements. A combination of technologies and/or the advancements in a technology or new technology will be required to meet the objective. The primary function of the device is height sensing, with the velocity sensing a secondary consideration for use in future near ground dynamic airdrop events not included in this topic.

DESCRIPTION: Airdrop cargo systems are being developed to more accurately land payloads on the drop zone at a reduced velocity and require reliable height and velocity sensors. The current height sensor is a stick of predetermined length extended beneath the payload that contacts the ground to determine the distance between payload and ground. To determine velocity, current barometric pressure sensors require further development to meet an acceptable precision while being cost effective or the developed height sensor will also have to determine velocity. The sensors need to be accurate to provide adequate time for the cargo systems to perform the necessary maneuvers (retraction/turn/slip/flare) to land properly. Specific minimum parameters will be provided to all offerors. Offerors are encouraged to discuss the airdrop environments and desired system capabilities with government personnel in advance of proposing. The system must be capable of functioning reliably in extreme environmental conditions.

PHASE I: Identify and define capabilities of sensors and appropriate components. Develop and conduct a trade off study to determine technical feasibility of components to be included in the proposal for Phase II work. A cost analysis/ projection will be conducted. Develop a cost/accuracy projection matrix for use in consideration of the Phase II.

PHASE II: Use results from Phase I to develop prototype design with preferred components. Fabricate three prototypes for bench testing, ground testing, followed by airdrop testing to demonstrate the sensors capability. Assist government personnel in a series of airdrop tests which will use prototype and current government instrumentation packages for comparison (locations TBD but most likely at the US Army Yuma Proving Ground). Information gathered during descent shall be easily downloaded to standard laptops and software packages to examine the data and compare to test range instrumentation data.

PHASE III DUAL USE APPLICATIONS: Further refinement of the system to make it suitable for a wider variety of airdrop applications. The entire airdrop community desires systems for velocity and height sensing. The height-sensing suite may also be usable for personnel jumps to inform the jumper when it is safe to release his equipment, and to prepare the jumper for impact during night drops or in other adverse weather conditions.

REFERENCES:
This topic addresses needs outlined in TRADOC Pam 525-66, Future Operational Capabilities (FOCs), http://www.tradoc.army.mil/tpubs/pams/52566frm.htm:


1) QM 99-001 & SF 98-605. Aerial Delivery/Distribution.
2) CSS 98-001. Battlefield Distribution.
3) CSS 98-002. Velocity Management.
4) Art 4.0-Perform CSS and Sustainment.
5) IN 97-300. Mobility-Tactical Infantry Mobility.
6) IN 97-301. Mobility-Tactical Infantry Deployability.
7) IN 97-321. Mobility-Soldier's Load.
8) TC 98-002. Force Projection Operations.
9) TC 98-004. Rapid Supply/Resupply of Early Entry Forces.
10) DBS 97-030. Mobility-Tactical Dismounted Mobility.


KEYWORDS: Airdrop, parachutes, cargo parachute systems, soft landing, instrumentation, wireless technologies, precision airdrop, and autonomous airdrop system

A03-189 TITLE: Tactical Guidance System for Military Free Fall

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO-Special Operations

OBJECTIVE: The primary objective is to develop, test, and demonstrate a system to enhance the capability of the Military Free Fall (MFF) Parachutist by increasing his capability to effectively reach his and his team's impact point in all environmental conditions. The desired system must be lightweight, low cost, and reliable, with ability to show primary and alternate impact points. It shall have all GPS functions to include, but not limit to altitude, L/D calculations, track to target, and algorithmic updates on odds of achieving impact point with quick mission planning updates to abort primary impact point and divert to one of the alternate impact points.

DESCRIPTION: The techniques for mission planning of MFF operations are extremely complicated, and the parachutist is burdened with a vast amount of details that are accumulated from several inputs. First map reconnaissance is done of the DZ prior to mission. From that reconnaissance, desired primary, alternate, and backup impact points are identified. During the mission phase of the operation, the MFF jumpmaster must calculate to adjust for wind and desired offset from the target and then determine a release point. When dealing with large offsets, the individual jumpers must have tremendous faith in both the pilot and navigators to have the team in the general area of the target and then the Jumpmaster to identify the correct release point. The individual MFF jumpers may or may not see any of the reference points upon exit due to environmental conditions and must possibly rely on buddy system, compass headings and or dead reckoning until they reach an altitude or position that can be recognized on the ground. If an in-flight emergency occurs and the team must exit, possible DZs are unknown. The research for the development of this product should consider the following issues:

· The system should allow the operator to interface with the unit with little or no reliance on hand motions. During freefall and under canopy, the operator hand movements relate to course adjustments, therefore inadvertent hand movements result in inadvertent course variations.

· The system should acquire GPS lock in little or no time after exiting the aircraft.

· Ideally the system should be equipped with heads up display technology. Looking at a chest-mounted device during freefall is awkward and could result in inadvertent head down attitude of tumble. Plus, chest mounts are difficult the see in high altitude operations when oxygen and oxygen masks are used.

· Showing the relative position on screen and voice communication of other jumpers via ICOMs is necessary to ensure all members are aware of mission changes.

PHASE I: Study existing equipment training tactics and procedures, to understand current operations and evaluate the tactical and commercial benefits to this new technology. Develop a list of technologies to assure maximum "hands-free" operations and, with government personnel, conduct a trade off study to determine the best features available. Explore and interview experienced military and sports parachuting personnel to assure maximum user satisfaction. Design and fabricate bread-board prototypes for demonstrating potential capabilities. Explore most effective methods of displaying/communication information to the users. Assure that system will seamlessly function with minimal integration into existing and anticipated future airborne warrior equipment. Acquire requirements and prioritize these requirements with government personnel for use Military Free Fall applications. Select components, altimeters, GPS, sensors, input devices, interteam communication devices, and information and format of information to be displayed. Then develop a design of a prototype system. Conduct ground tests and demonstrate the systems accuracy and ease of use. Fabricate a number (3 minimum in this phase) of prototypes for bench testing. Select and develop a trade off study of additional sensors/capabilities for the package that will be proposed for Phase II work. A cost analysis/projection will be conducted.

PHASE II:. A final selection of system and a final design of the miniature instrumentation package will be completed. A number of systems (minimum of 10) will be fabricated. Test and assist government personnel in a series of airdrop tests that use current government instrumentation packages for comparison. A simple download capability will be added for use in standard laptops and a software package to rapidly examine the data through a graphical user interface (developed in consultation with the government) will be completed and demonstrated. A course history log with flight characteristics and operator inputs should be included in the software. The software should be open source to allow the user to tailor the output for the specific tests but must also include the most standard features via the GUI. Prioritization of the desired additional capabilities will be conducted during proposal generation with the government.

PHASE III DUAL USE APPLICATIONS: The Military Freefall community desire systems for maximizing the ability to safely reach a desired impact point. They may also be valuable for recreational parachuting activities. The ability for the user to rapidly download and examine parameters of the flight is desired and additional features to "re-play" the flight graphical flight log would have a high marketability. It could be used as a personal black box to not only guide, but also show what went wrong during a flight in order to improve future operations.

REFERENCES:
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2) SOCOM Field Manual 31-19, Military Freefall Parachuting Tactics, Techniques, and Procedures.

KEYWORDS: Military Freefall, GPS, Guidance, Heads up display, Altimeter, Impact point, Release point

A03-190 TITLE: High Performance Shelter Insulation with Reduced Weight and Cube

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Recent manufacturing technology advances have been made creating porous silica or ?aerogels? that provide excellent thermal insulation. The technology is now becoming affordable for consideration in military shelter applications. The objective of this effort is to address specific technology issues related to incorporating aerogels into a textile-based insulation material for tents that is effective, lightweight, flexible, flame resistant, durable and affordable.

DESCRIPTION: The U. S. Army shelter systems must be rapidly deployable in a variety of external environmental conditions while providing a comfortable internal environment. There are two currently used methods of providing insulation for a military tent. The first method is the use of a stagnant air space between two layers of a shelter wall. This method does not provide sufficient insulation in extreme hot and cold environments. The second method is to hang a quilted blanket on the interior of a shelter. This insulation is a fiberglass/polyester/Mylar composite several layers thick. The material provides sufficient insulation but significantly increases the cube and weight of a system. Silica is well known for its inflammability and high thermal resistance. The lack of a highly efficient, low weight and packing cube shelter insulation drives the interest in this well-known material. The goal is to fabricate a nano-porous structure using silica to create an insulation applicable to shelters. Such materials can provide an R-value (thermal resistance) of 13 per inch thickness, compared to an R-value of 6 for the current composite (MIL-C-44154B). This aerogel-based insulation would significantly reduce the weight and cube of a system while providing at least the same level of thermal resistance. It must be cost effective, durable, and non-combustible. The thermal protective capabilities of nano-porous silica have been proven in outdoor sporting equipment, lightweight cold-weather jackets, and thermal blankets. Some added features of nano-porous silica are elimination of thermal signature and sound barrier.

PHASE I: Leveraging existing manufacturing technology for aerogels, explore fiber and textile substrates for integration with the aerogel with the goal of producing a lightweight, flexible, flame resistant, durable and affordable, high R-value insulation for military shelters approximately 200 square feet and larger. Assemble potential configurations and conduct laboratory testing. Evaluate flame resistance and cost. Deliver a report that documents the materials considered, test results and a suggested plan for future work.

PHASE II: Based on the results from Phase I, determine the best aerogel/textile configuration that produces the insulation material with the optimum thermal resistance coupled with low manufacturing cost. Optimize the insulation material for flame resistance, durability, and flex fatigue. Fabricate the insulation material with a developed method of shelter integration. Produce a report with material design, properties and specifications, analysis of performance, and evaluation of the potential for full-scale success.

PHASE III DUAL USE APPLICATIONS: The only shelter material that is used in the U. S. Army is heavyweight and bulky. With high mobility and sustainability requirements, all branches of the military would benefit from a lightweight thermal insulation material. This material would reduce the weight and cube of shelter systems while reducing climactic loads on internal shelter environments. If successful, this technology could transfer to individual protective equipment and civilian applications.

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www.naima.org
4) MIL-C-44154B, Cloth, Insulation, Multiple Layer Composite, Quilted, Flame Resistant.


KEYWORDS: Tents, Shelters, Insulation, Porous, Silicon, Silica, Thermal Resistance, Aerogels

A03-191 TITLE: Body Conformal Integrated Personal Area Network

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM - Soldier Systems

OBJECTIVE: Develop body conformal integrated personal area network that is capable of transmitting power and data, and supporting electronic subsystems such as a personal wearable computer, communications, sensors, and GPS.

DESCRIPTION: Electronics are being miniaturized for personal use and there are efforts to integrate these electronic subsystems into protective clothing. The cables and connectors supporting these electronic subsystems are round and have a fairly large diameter. The cables are rigid and stiff, and generally extend away from the body making them difficult to integrate into clothing and vulnerable to snagging. A wearable electronic network is desired that transports power and data, is body conformable or stretchable, is ergonomically designed so that the placement and routing of the network is unobtrusive, and the connectors are low profile and comfortable to wear.

PHASE I: The technical feasibility to integrate a body conformable personal area network into clothing will be established. Methods to manufacture stretchable or otherwise body conformable materials that transport data and power will be investigated. Testing shall be proposed to evaluate electronic performance after stretch, laundering, bending and twisting, fatigue, and abrasion. Low profile connectors will be designed. Test methods shall be proposed to evaluate network to connector strength, waterproofing and wear. A clothing system's level network shall be mapped and supporting cables and connectors will be designed and proposed. A database to document, evaluate, and resolve human factor's issues will be proposed. The target network shall also be safe to wear, lightweight, flexible, washable, and EMI shielded. The most effective designs, materials, manufacturing processes, and test methods will be determined and proposed for Phase II efforts. The basic technological components are integrated to establish that the pieces will work together (TRL 4). A report shall be delivered documenting the research and development supporting the effort along with a detailed description of materials, processes, and associated risk for the proposed Phase II effort.

PHASE II: The contractor will develop and demonstrate one working prototype of the body conformal integrated personal area network within a two-piece clothing system with the performance in accordance with the goals in Phase I. The basic technological components shall be integrated so that the technology can be tested in a simulated environment (TRL 5). A report shall be delivered documenting the research and development supporting the effort along with a detailed description and specifications of the materials, designs, performance, manufacturing processes, and human factor's database.

PHASE III DUAL USE APPLICATIONS: Wearable computing systems for the following applications: 1) Safety - Improved situational awareness and survivability of personnel in Fire Service, Law Enforcement, and Urban Search and Rescue. 2) Just-in-Time-Learning - Storage and retrieval of manuals for use in electronics inspection and repair of large systems such as mail sorters. 3) Medical Applications - Access to real time information on physiological status of patients. Prototypes shall be capable of being tested in a simulated operational environment (TRL 6).


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KEYWORDS: Textiles, Electronics, Smart Textiles, Information Technology

A03-192 TITLE: Active Package Olfaction to Increase Soldier Acceptance of Field Rations

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Joint Proj. Dir., Combat Feeding

OBJECTIVE: a) Develop a packaging-based technology to improve the olfactory appeal of military rations intended for field use, to increase the acceptability and therefore consumption of rations. b) Explore the potential of olfactory agents to influence short-term behavior in field personnel.

DESCRIPTION: Field rations are manufactured well ahead of time, and at the point of consumption are considerably different in their sensory qualities from freshly prepared meals. This is a result of both the processing of food during the filling/packaging operation and the slow thermo-oxidative changes that occur during storage. The chemical changes that take place within a food package over time reduce the appeal of otherwise palatable food items. This results in under-consumption of rations, which has been proven to have a deleterious effect on the warfighter's nutritional and hydration status, and ultimately his or her performance. Any improvement in the appeal of rations is therefore highly desirable.

Sensory appeal of food is well known to be predominantly due to olfaction or aroma. It is the loss of volatile olfactory agents from the food during storage or processing that is primarily responsible for the reduced appeal of field rations. Recognition of food as being wholesome and acceptable for consumption is almost entirely determined by how closely the olfactory signature of the food agrees with that of the same food item freshly-prepared. The acceptability of rations should therefore improve considerably by replacing the missing parts of the olfactory signature using appropriate additives in the packaging materials (as opposed to the food itself). Embedding the appropriate non-toxic olfactory agents in ration packaging systems is the primary approach to improving the appeal of the rations. Upon opening an olfaction food package at point of use, an aromatic signature will improve acceptance, consumption and nutritional status.

A secondary aspect of the topic is to research the potential impact olfactory agents have on the short-term behavior and morale. Olfactory agents are reported to have a proven effect on physiological factors such as appetite, morale, alertness, relaxation, aggression and cognitive skills. Olfaction packages could be used to elicit short-term behavioral responses when desired for specific missions. For example, they could enhance cognitive skills, alertness or aggression during an intense conflict; suppress appetite, thirst or enhance morale in survival situations; or improve endurance and productivity during recognizance missions.

Ration packages provide a reliable and consistent means of delivering the aromatic factors to field personnel. The result of this SBIR effort will be the demonstration of a novel active package technology that is capable of delivering olfactory agents via controlled release from ration packaging materials.

PHASE I: Identify the critical olfactory signatures of at least two food components of combat rations. Demonstrate the feasibility of using a packaging-material based release of appropriate olfactory agents to enhance the olfactory signature of these items. This would include the determination of the levels of olfactory agents needed in the plastic films to achieve the desired threshold odor levels in the package. Demonstrate through consumer panel tests the increased acceptability of the items employing the novel packaging materials with enhanced olfactory signatures compared to control ration items. Through a combination of literature and market research, document those areas where odorants have the potential to influence short-term behavioral and/or psychological responses. Based on this documentation, propose research studies to assess short-term behavioral/psychological response potentials (i.e., brief exposures to candidate agents in which possible behavioral effects are determined by used of questionnaires administered before and after exposure). For those odorants showing promise in either past or proposed research, follow on research could be developed to measure behavioral or psychological outcomes over short-term (hours) periods. Prepare a limited database of physiological and psychological impacts of the olfactory agents relevant to soldier performance.

PHASE II: Carry out analysis of the more effective and economical ways of implementing the packaging technology, particularly the use of aromatic inserts versus direct incorporation of agents into the plastic packaging film. Investigate the processing variables involved in dispersing the olfactory agents in blown plastic film materials. Through accelerated oven aging tests, establish the lifetime of the olfactory agents in the plastic matrix. Establish the impact of the olfactory additives on the mechanical integrity of the plastic film material in which it is incorporated. Prepare documentation to establish the non-toxicity and environmental impacts of the use of this technology. Develop prototype olfactory materials to demonstrate successful application of the technology with packaged food items. Add to Phase I database a list of olfactory agents, the threshold levels, feasibility of release through a plastic matrix, cost of the aromatic agents, ease of manufacturability, and summarize reported data on the changes effected by the agents.

PHASE III DUAL USE APPLICATIONS: The possible commercial applications of this active packaging technology are numerous. Olfaction packages will impart a fresh-like aroma and quality to store-bought shelf stable, refrigerated or frozen foods. Package induced 'aromatherapy' could be used extensively in the weight-control or food service industry to suppress or enhance appetite, mood or morale. In the holistic, health foods or performance foods market, olfaction packaged foods have the added benefits of increasing thinking or problem solving skills, endurance, productivity, alertness, etc. In the medical field, aroma packages can be used to boost the immune system or cause cephalic phase responses which may influence nutrient absorption.

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KEYWORDS: active packaging, olfaction, olfactory agents, aromatherapy

A03-193 TITLE: Rigidification of Flexible, Inflatable Composite Structures

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM- Force Sustainment Systems

OBJECTIVE: Develop the materials and techniques of providing field rigidification to rapidly deployable inflatable airbeams that are used as frames for fabric-skinned structures to provide enhanced durability for long-term deployments.

DESCRIPTION: Recent advances in inflatable airbeam technology have resulted in lightweight structures that can be rapidly deployed to accommodate highly-mobile military missions as well as quickly establishing logistics support facilities at ports and across the battlefield. Some functions require the fast deployment offered by airbeams but are long-term facilities where maximum durability and minimal maintenance are high priorities. These uses can benefit from the ability to utilize an inflatable structure for deployment which is then rigidified for long-term use. Military users often ask about the airbeam's ability to withstand punctures due to bullets, schrapnel, etc. Post-deployment rigidification offers a solution to this technical barrier. It is not the intention to make airbeam structures bullet-proof but to eliminate structural collapse if unintentionally deflated.

To date, NASA has lead the research in rigidification of inflatables. Inflatables offer significant weight and cube advantages, which provide large cost reductions to get structures into space. Rigidifying inflatables in space is desirable as micro-meteorites are a constant threat in space. Technology approaches have included heat or UV curable resins that in some cases can be reversed in order to repackage the item.

PHASE I: Address technical feasibility issues related to rigidifying flexible inflatable composites including structural performance, energy requirements to activate, weight, cube and cost considerations. Explore the most promising concept and demonstrate in a sub-scale prototype system.

PHASE II: Advance the technology demonstrated in phase I and scale-up to a full-size system. Fabricate a prototype shelter based on the technology and conduct testing to prove-out technical and operational performance. Address all manufacturing technology issues related to proceeding to production.

PHASE III DUAL USE APPLICATIONS: Inflatables have many dual use structural applications where rapid deployment is beneficial but post-deployment rigidification offers long-term use. Potential uses include dams, bridges, space structures, commercial construction, antennas, etc.

REFERENCES:
1) An excellent overview of this technology along with many references can be found in "Rigidizable Materials for use in Gossamer Space Inflatable Structures", David Cadogan, Stephen Scarborough, ILC Dover, Inc., April 2001. This paper is available online at: http://www.ilcdover.com/WebDocs/AIAA2001-1417.pdf

KEYWORDS: inflatable, textiles, airbeams, shelters, tents, structures, rigidification, composites

A03-194 TITLE: Enhanced Lethality Munitions for Army Applications

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop leap ahead technologies in high performance structural materials such as nanostructured materials and/or the processes used to produce them. Emphasis should be placed on structural materials whose grain structure provides property enhancement such as high strength at operational temperatures, very high specific stiffness, or novel characteristics such as structural thermite intermetallics that would result in more capable and lethal systems. Cost effective fabrication technologies that are scalable to production are of interest.

DESCRIPTION: Over the last decade substantial progress has been made in the area of high performance materials (specially in nanostructured materials). Laboratory discoveries offer the promise of significant increases in mechanical, electrical and other properties. Relatively limited progress has been made in developing large scale manufacturing capability and transitioning these discoveries to real-world applications. Missile defense systems require a host of high performance materials in hardware to detect, discriminate, intercept and most important to destroy hostile offensive systems. Therefore, substantial latitude is left to interested firms in proposing advanced materials concepts that could be applied to these needs. Promising technology areas include, but are not limited to, thermal or kinetic spray forming process for producing well characterized nanoscale grain structures, rapid solidification with in situ nucleation techniques, and high rate processes for producing well characterized nanoparticles. Proposed efforts should seek to provide revolutionary performance improvements with emphasis on structural material systems. Such enabling materials and process technologies would be readily adaptable to commercial applications, providing for dual use applicability.

PHASE I: Analyze, evaluate and conduct feasibility experimentation of the proposed advanced materials to include material characterization and fabrication.

PHASE II: Demonstrate feasibility of engineering scale up of proposed process; identify and address technological issues, and characterize the performance of the novel materials. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The availability of a cost effective process to produce high performance structural materials for missile defense applications could have critical impact on fielding an effective system. Improving system performance(velocity, lethality) with equivalent or lower costs could be the result of successful development. Equaly important is the transferability of such process technology to highly critical commercial applications in aerospace, sporting goods, automotive and industrial uses.

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2) A. Thes et al, "Crystalline ropes of metallic carbon nanotubes", Science, Vol. 273, July 1996.
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KEYWORDS: Nanomaterials, lethality, reactive materials, munitions

A03-195 TITLE: Advanced Algorithms for Tomographic Imgaging

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop advanced algorithms to identify and characterize low-observable flying overhead targets, such as an unmanned-aerial vehicle (UAV), in near-real time.

DESCRIPTION: Laser tomography is being investigated as an alternative approach to more traditional surveillance techniques used in RF radars for platform identification and characterization of low observable aerial platforms. Laser reflection tomography offers consistent resolution for all target ranges, as the resolution is determined by the laser pulse width and detector response time, and the imaging is done temporally, not spatially.

One of the technical challenges of the reflective tomography approach is to rapidly compose, in near-real-time, a two dimensional tomographic image of the interrogated platform to support rapid threat assessments. Once the tomographic image has been generated, the imagery data is then utilized to determine platform identification and is input into assessment algorithms to determine the operational intent of the platform.

The tomography algorithms must be able to generate images of targets that are non-rotationally symmetric and be able to account for variation in the axis of rotation of the target with respect to the ground observation point. These assessments must be accurately performed in near real time.

PHASE I: Identify a potential algorithm approaches for generating near-real-time two dimensional tomographic imagery to be used for platform identification and determination of operational intent while taking into account the variation in axis of rotation from the ground observation point. Propose a top-level design for a simulation to test the performance of the proposed algorithm approach, using “notional” threats developed by the offeror. Suggest metrics for validating the proposed simulation and for evaluating the performance the proposed algorithm.

PHASE II: Design, build, prototype and test the simulation and the advanced algorithm proposed in Phase I. Prepare functional trade analyses to show the impact of number of target aspect angles and number of range returns to the processing (computational) time. Compute metrics and assess findings.

PHASE III DUAL USE APPLICATIONS: Laser tomography, with the proper advanced algorithms, could be used to support identification of aerial platforms, for a variety of battlefield and commercial applications, including homeland security. This algorithm could also be used with the imaging technologies currently in the medical community, to support faster diagnosis and treatment.

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KEYWORDS: LADAR, Laser Imaging, Reflective Tomography, Computed Tomography

A03-196 TITLE: Explosive Pulsed Power

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objectives of this effort are to develop explosive pulsed power systems that can be used to produce small to medium caliber munitions (40-mm to 155-mm) capable of producing effects in addition to blast and fragmentation.

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, can attack sensitive electronics and may have longer lethal ranges than blast waves and fragments. Activated materials, such as aerosols, 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. One of the critical technologies that will enable the development of multi-functional munitions by providing sufficient electrical power from a very compact and rugged package is explosive driven pulsed power. Current capacitive and inductive energy storage technologies do not provide sufficient energy or meet the severe mass and volume requirements imposed by the munitions being considered for development.

PHASE I: Identify potential explosive driven pulsed power systems and their associated power conditioning and analyze, design, and conduct proof-of-principle demonstrations to: 1) verify that outputs are predictable and are consistent with predictions, and 2) to assess their suitability for use in a variety of munitions to include packaging and ruggedization.

PHASE II: Design, build, and test enhanced prototype explosive pulsed power systems and/or their critical components and verify their capabilities. Design production process for mass production.

PHASE III DUAL USE APPLICATIONS: Explosive pulsed power systems are being considered for oil and mineral exploration, propulsion systems and electromagnetic launchers, rapid charging of capacitors, magnetized target fusion, and destruction of chemical and biological agents.

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KEYWORDS: Pulsed Power, Marx Generators, Magnetocumulative Generators, Magnetic Flux Compression Generators, Ferroelectric Generators, Piezoelectric Generators, Ferromagnetic Generators, Switches, Transformers, and Power Conditioning

A03-197 TITLE: <u>Engineering Models for Reactive Munitions</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop engineering models and computer codes that would predict the damaging effects of reactive interceptors on targets of interest such as ICBMs, tactical ballistic missiles to include chemical and biological submunitions, etc. Specificaly, along with the structural parameters,pressure gradients, etc. the chemical exothermicity of reactive interceptors will be incorporated into the models.

DESCRIPTION: The Army is striving to develop more effective interceptor systems. Interceptors utilizing reactive materials offer the potential of enhanced effectiveness over conventional interceptors. Analytical tools are required to evaluate new interceptor concepts, optimize their designs, and evaluate their effectiveness. Testing of reactive interceptors is expensive, results can not be extrapolated, and use of hydrocodes is limited by the absence of the chemical and physical phenomena taking place during the interaction period. Therefore, there is a need to develop new modeling concepts which incorporates the chemistry and the properties of the reactive materials in order to predict behavior of reactive interceptors and target response and damage accurately.

PHASE I: Develop a simple model that incorporates the parameters involved in controlling energy release rates and effects on targets of interest. The model could be parametric. Model target/reactive munitions and determine parameters that determine the outcome of the interaction.

PHASE II: Use the results from the Phase I to expand into detail models that include energy rates, pressure gradients, forces, structural properties and realistic targets. Develop the code that provides lethality assessment answers and plan experiments to validate models.

PHASE III: The engineering models and codes will be implemented into the lethality community. The modeling developed under this topic will be used in the commercial sector in areas such as pyrotechnic devices that are used in the air bag industry, ejection seats, and demolition industry.

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KEYWORDS: Reactive, simulation, lethality

A03-198 TITLE: Compact, Rugged Ultra Wideband Antennas

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop compact, rugged ultra wideband antenna technology that can be used in the DOD environment to produce small to medium caliber munitions (40-mm to 155-mm) capable of producing directed energy effects in addition to blast and fragmentation, as well as non-weaponized commercial ruggedized systems.

DESCRIPTION: In the military environment, 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, through the development of multifunctional warheads. A directed energy component, such as high power microwave or ultra wideband signals can attack sensitive electronics and may have significantly longer lethal ranges than blast waves and fragments. One of the most critical technologies required to achieve these capabilities are compact antennas that can radiate energy over a broad frequency band and that can survive high g-force launches. Current capability in this technology area is highly limited, and additional applied research and development is critical in antenna's in order to enable development of this type of system. This type of enabling technology will also have significant commercial impact in compact ruggedized radars, and communications equipment.

PHASE I: Identify potential compact ultra wideband antennas, such as fractal, plasma, and other innovative antennas, and conduct proof-of-principle demonstrations to: 1) verify that outputs are predictable and are consistent with predictions and 2) to assess their suitability for use in a variety of munitions to include packaging and ruggedization.

PHASE II: Design, build, and test enhanced prototype compact, rugged, ultra wideband antennas and verify their capabilities. Design production process for mass production.

PHASE III DUAL USE APPLICATIONS: Compact, ultra wideband antennas are being considered for use in a variety of non-DOD markets such as deployable weather radars, ham radios, field radios, and cell phones.

REFERENCES:

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KEYWORDS: Fractal Antennas, Plasma Antennas, Tapered Spiral Antennas with Autotransformers, Ultra Wideband Radiation, and Unconventional Antennas.

A03-199 TITLE: Army Directed Energy Weapon Systems Deployability Enhancements

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop enabling technologies in high energy chemical lasers, which will enhance their field utility and deploy-ability for the U.S. Army. High power laser weapon systems have the potential to provide precise, high probability of kill, low cost per kill, and multiple hits on target. They will also provide a force shield through protection of early entry forces, and engagement of rockets, artillery, and mortars. Chemical lasers have very high average power levels, but suffer from packaging and logistics issues. At these high power levels, multiple air and missile defense missions are achievable. Advanced HF/DF and COIL chemical lasers require improved hazardous chemical handling that is needed to reduce the vulnerability and improve the supportability of potential future military chemical laser systems. To fully realize these potential benefits, key enabling technological advancements are needed.

DESCRIPTION: Directed energy weapon systems must be rapidly deployable, rugged, reliable, efficient, maintainable and sustainable. Fluorine (and Chlorine in COIL lasers), Nitrogen Tri-fluoride (NF3) and other toxic gas handling is a primary concern with proposed U.S. Army chemical lasers. Innovation is required to improve the performance of basic mechanical/chemical handling components such as valves, couplings, pressure regulators, and pressure vessels making them less likely to leak toxic/reactive gasses and more able to withstand battlefield conditions. Such improvements would make the weapon system less vulnerable with improved safety and reliability. For example, valves with extremely precise sealing ability and precision wear surfaces that prevent even minute particulates from entering reactive gas streams are needed. Materials research (or creative inorganic chemistry) into finding a metal hydride or similar material that could store NF3 and release it for extended time durations at relatively low pressures would also be of interest. Another interesting development would be making pressure vessels that were shock resistant or shock tolerant with mechanically robust passivation layers. Chemical lasers need these kinds of improvements in packaging and reliability to make the systems more robust and lessen the impact of logistics issues.

PHASE I: Analyze and evaluate new concepts or designs and conduct proof-of-principle experimentation.

PHASE II: Design, fabricate, and test prototype-scale device or components. Conduct parametric assessments. Demonstrate improvements of new concept/design over existing technologies.

PHASE III: In addition to direct applicability to Army Directed Energy programs, enhancements to the reliability of chemical lasers with a wide range of average powers would have commercial applicability in industrial operations, materials processing, imaging, and remote sensing. Improved gas handling would also benefit the semi-conductor fabrication industry and the industrial gas process industries.

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5) Bauerle, D., Laser Processing and Chemistry, Third Edition, Springer-Verlag, (2000)

KEYWORDS: HF, DF, Chemical Lasers, Nd, Yb, Er, Solid State Lasers, Fiber Optics, Toxic Chemical Handling Equipment, Laser Diodes

A03-200 TITLE: Advanced Virtual Environment Haptic Simulation

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Virtual Emergency Response Training System & VLET

OBJECTIVE: Research and develop the immersive and haptic technologies and their interfaces to allow a Soldier, first responder, or medic to have a sense of touch and feel in a virtual environment. The systems would add a level of realism and fidelity to the virtual environment to further immerse an individual into the simulation. These applications would support Army operations in the areas of Military Operations in Urban Terrain (MOUT), first responder handling of a Weapons of Mass Destruction incident, and training for medical personnel.

DESCRIPTION: Current immersive virtual environments do not have the capability of allowing the trainee to “feel” or interact physically with the environment that they are immersed in. This topic will address the capability and functionality of providing an immersed individual with a sense of full body feeling in the virtual world.

These new capabilities would allow for the simulation of things such as: opening a door, feeling if a door is hot (fire in the room), feeling the heat from a fire, determining where you have been shot, taking a person’s pulse, feeling if a virtual person is breathing, determining if someone has a fever by touching their virtual head, and etc. Once these technologies and interfaces are developed, the virtual environments currently in use by the Army could be supplemented with the technology to add another level of realism.

Current haptic capabilities allow someone to have a sensation on their fingertip or other area when they touch a virtual button or a virtual wall. Also, in order to prevent movement through an object such as a wall or a door the haptic device would be very bulky, cumbersome and in most instances tethered to the floor or wall. In the Army’s simulations, these same feedback senses need to be felt but with a compact, non-intrusive system that is not tethered to anything. Additionally, the feeling of a combat wound needs to be felt so that a soldier knows that he has been shot. COTS systems cannot provide this level of realism.

PHASE I: Investigate haptic systems and interface requirements for basic tasks, environmental feedback, and medical diagnosis and treatment simulation applications for virtual simulation systems. Examples of such systems would be those supporting dismounted infantry, weapons of mass destruction responder communities, and the medical community. Develop a concept system design that would perform the following tasks:

- Allow for the sense of touch, pressure, and temperature
- Provide feedback to soldiers and/or medics in a variety of applications as described above
- Programmable so that, as new requirements are identified, the system can be programmed with these new feelings (i.e., getting feedback from a bomb blast)
- Be non-obtrusive or bulky
- Be untethered

Develop a report detailing the findings from the investigation and produce a system design concept.

PHASE II: Develop a proof-of-principle simulation system based on Phase I design concept. Develop appropriate and novel user interfaces and virtual environment elements to support tasks being performed by dismounted infantry in MOUT environments, responses to nuclear, biological or chemical incidents, casualty diagnosis and generalized field treatment. The system should meet the requirements detailed in the Phase I report. When complete, the user will have the ability to feel different types of objects and temperatures in the virtual environment. Additionally, the system will prevent the user from reaching through doors or walls in the virtual world. The system should be tested in the Army’s immersive simulation system to verify the designs.

PHASE III: Develop and market the application to military and civilian organizations that deal with first responder applications. These could include emergency medical personnel, firefighters, and law enforcement agencies.

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4) "Simulation Capabilities for Dismounted Infantry in the Urban Fight," Published paper by Michelle Mayo, Jim

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KEYWORDS: Haptic, first responders, weapons of mass destruction, dismounted infantry, MOUT (Military Operations in Urban Terrain), medical, simulation, virtual environment

A03-201 TITLE: Automated Tool to Model Software for System Performance Predictions

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEOSTRI - PM WARSIM - JSIMS Land

OBJECTIVE: To develop a tool that automates the process of modeling large software programs for the purpose of predicting system scalability and for facilitating what-if design changes.

DESCRIPTION: Large-scale software projects, such as modern DoD constructive simulations, face challenges meeting their target performance goals within reasonable budget constraints. One promising approach toward this problem is to create simulations of the software to understand the complex interactions between sub-systems and to predict how the software will perform under various system loads and hardware configurations. Software improvement efforts can be prioritized and directed by analyzing simulation results to determine which sub-system improvements would have the greatest system-wide impact.

Creating a valid simulation of a large software system requires a significant and dedicated effort, increasing costs and inherently limiting time available to analyze the results of the simulation. The purpose is to accelerate the software performance analysis process through the development of a tool that automatically creates a simulation of large software systems. The automated process would include four distinct phases: 1) modeling the structure of the program, 2) measuring program performance, 3) appropriately fusing performance data to the model to create an accurate simulation, and 4) predict system scalability.

PHASE I: Investigate current software tools for their capability in process modeling for constructive simulations. Develop techniques for measuring the overall software program performance, fusing performance data to the individual models and providing the ability to predict the system's scalability. The results of phase I would be the integration of the techniques into an architectural design concept of an automated tool.

PHASE II: Develop a prototype tool based on the Phase I architectural design concept. Test the automated tool by selecting programs of varying sizes and complexity to show how the tool models the program structure, measure the program performance, predicts the system's scalability and fuses the data into a final simulation. This tool should interface with existing commercial automated case tools.

PHASE III: Commercial development efforts could also benefit by simulating their own software to achieve better performance predictions and better analysis insights. This tool can be utilized on any software program that has to perform real time or faster than real time, for example, commercial flight software, mission critical software, internet/financial software, etc. The goal is to help the software crisis by automating the simulation of the software and predicting system performance. Analysis of performance-constrained DoD simulations could proceed more rapidly and with greater insight. The automated tool will mitigate the risk of system performance by identifying where software improvements can be made and have the greatest system-wide impact.

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KEYWORDS: automated tool, model, software, simulation, system performance, prediction, analysis, constructive, scalability.

A03-202 TITLE: High-Precision, Expendable, Six Degree-of-Freedom Sensor

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO STRI/PM TRADE (OneTESS Program)

OBJECTIVE: Design and build a six degree-of-freedom sensor that can be manufactured at very low cost and is capable of very accurate measurement of three linear and three angular acceleration components. The sensor must be small in size, light weight, consume little power, and shock resistant, to be suitable for embedment into weapons such as the XM29. This capability is a key enabler for line-of-sight and non line-of-sight (NLOS) tactical engagement simulations - an FCS ORD Key Performance Parameter for training.

DESCRIPTION: Tactical engagement simulations conducted during training exercises are currently accomplished with lasers (MILES) that have serious disadvantages: they are not intrinsic to the design of the weapon (appended), are heavy, consume lots of power, and cannot simulate NLOS engagements between the shooter and the target. What is required is a small, light weight, low power sensor that can be embedded into a rifle with a cability to determine a pointing vector at, or near, the weapon's own ballistic accuracy.

The government has spent considerable amounts of R&D funds developing micro electro-mechanical systems (MEMS) inertial measurement units (IMU), however, technical barriers beyond size are also high risk. For instance, MEMS IMU performance is inversely related to size and their fundamental limits are determined by thermal noise. Additionally, even with significant reductions to size, weight, and power through MEMS technology, the combination of low price, to the point of being expendable, and high performance are also significant barriers. There are potentially different approaches to sensor development that can deliver high performance yet mitigate or even eliminate significant disadvantages that MEMS-based IMUs have, such as high drift rates, calibration requirements, high cost ($1200 and up) and sensitivity to temperature changes. The goal of this sensor development will be to achieve a drift rate of less than 0.3 degrees per hour and a size, weight, and power suitable for embedment into dismounted soldier weapon systems and unmanned platforms. It must be low cost (less than $200 per unit in quantity), be shock resistant, require little or no calibration, and be insensitive to temperature changes.

PHASE I: Define sensor capabilities/characteristics, create a design concept, perform a design analysis (with tradeoffs) that includes an assessment of the feasibility to meet the tactical engagement simulation requirements (accuracy, size, weight, power consumption) and cost goals.

PHASE II: Fabricate and test a prototype sensor. Write a report that evaluates the prototype's capabilities, limitations, and addresses its feasibility to meet tactical engagement simulation requirements (accuracy, size, weight, power consumption) and cost goals.

PHASE III DUAL USE APPLICATIONS: As an input/interface device for FCS, remote controlled toys, computer aided drawing, computer gaming, underground boring, and as a navigation aid for unmanned platforms in GPS denied environments.

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KEYWORDS: sensor, accelerometer, gyroscope, inertial sensor, six degree-of-freedom, tracking, magnetic fluid based accelerometer

A03-203 TITLE: Trainning Performance Assessments for Mixed Initiative (Manned/Umanned) Team

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To develop a method and mechanism to assess and determine criteria for successful performance of unmanned systems and manned/unmanned teams in both the real world and in training environments. The OneSAF Testbed Baseline (OTB) in conjunction with the Advanced Robotics Simulation Science and Technology Objective (STO) Program are possible baselines for the research effort. The resulting work must facilitate performance assessment & measurement of unmanned systems and manned/unmanned teams.

DESCRIPTION: The Objective Force will employ robotic systems in intelligence collection and as a force multiplier. Many tactical robotic systems are difficult to utilize; requiring a high level of operator training and control to optimize their tactical employment. Currently, the training of procedures and tactics for the employment of new robotic systems in the battlespace are limited and need to be developed and refined. The Army currently does not have the capability to evaluate and understand the effectiveness of Mixed Initiative teams of manned and unmanned systems. Simulating robotics systems within Computer Generated Forces (CGF) will provide a low overhead driver and analysis capability for Future Combat System development. It is critical that the Army understands how to best fuse the strengths of the human with the strengths of the unmanned systems. It is equally important that we develop appropriate metrics to assess the performance of these teams. Current robotic control technologies cannot meet future requirements based on more demanding deployment criteria and more hazardous threat environments. Improved understanding of the Mixed Initiative team resulting from this research will provide corresponding advantages to the commercial simulation business, and burgeoning entertainment market as well as applications to Homeland Defense activities.

Phase I: Develop a method and mechanism for performance assessment of manned/unmanned systems within the Advanced Robotic Simulation Environment. The resulting work must consider the man/machine interface as well as team performance metrics for Mixed Initiative teams.

Phase II: Enhance and complete the method and mechanism developed in Phase I and conduct performance assessment experiments with Mixed Initiative teams in both the laboratory and in the field. The experiments should support an operational scenario and, when possible, include teams of soldiers and unmanned systems. If possible, the government will provide access to operational settings for the experiment (such as the MUCT site at the Unit of Action Maneuver Battlelab in Fort Knox, Kentucky).

Phase III: The performance assessment tool could help the emergency response team to decide when to utilize mixed initiative team on a particular type of mission (such as in a contaminated urban area, bomb disposal, etc). As robotic systems get integrated into the entertainment, homeland defense and future military environments the performance assessment tool will play a critical role in building and assessing mixed teams.

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KEYWORDS: Robotics behaviors, team performance, unmanned vehicle, CGF, SAF, OTB

A03-204 TITLE: Adapting Intelligent Tutoring System for Assessing Collaborative Skills

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Digitized Training

OBJECTIVE: The purpose of this research is to investigate how Intelligent Tutoring Systems (ITS), which have been historically oriented toward providing instructor-less individual training, can be utilized to provide coach-less team training. This research will produce an advanced ITS capability which can be incorporated in PC-based or web-based simulations and provide an effective training mechanism for massively multi-player games.

DESCRIPTION: This topic seeks to extend the state of the art in ITS development by selecting an existing ITS that focuses on an individual task performance and expanding the ITS to incorporate small group performance. Conventional ITSs consist of three models: Student, Expert and Instructor. This topic will research what innovative work is required to develop a team training ITS. The resulting ITS will go beyond providing individual-level instructor-less assessment and feedback, instead focusing on the collaborative training needs of various Army teams (e.g., infantry squad, armor company, battalion staff). The research will document the differences in developing ITS models used to support an individual training event vice the models used to support a team training event. The models will focus not only on the individuals in a group, but will also focus on the team as an individual entity. The lessons learned from this research will be invaluable in developing more sophisticated, collaborative ITSs in the future. This topic is focused on the technology required to produce an ITS, as opposed to the psychological side of human team performance and behavior.

PHASE I: This is a 6-month effort to test the scientific, technical and commercial merit and feasibility of the team training ITS. Phase I research efforts will include:
- Research survey of existing ITSs, with particular attention to ITSs shown to be useful for training military-oriented tasks, principles and doctrine
- Evaluation of differences of individual versus team skills for the same type of operations (e.g., intel officer skills compared to role of intel officer on staff, or infantry soldier skills compared to infantry squad skills) based on existing research from such organizations as Army Research Institute (ARI)
- Definitions of ITS models that will provide for collaborative team training and their internal and external interfaces
- Architecture for ITS/PC-based simulation to provide individual as well as team assessment/feedback
- Additional architecture/framework for integration of a massively multi-player game and team-oriented ITS
- Description of a simulation-based training event oriented toward training a small Army team (e.g., infantry squad, armor company, battalion staff). The training event must be one that is able to show the application of the ITS to both individual & team skills

The projected outcome of Phase I will be a research report detailing the above items, as well as a plan for a prototype to be delivered during Phase II.

PHASE II: This is a 24-month effort to develop the team training ITS to the prototype stage. Phase II research efforts will include:
- Building a new ITS or (preferably) adapting an existing ITS to provide both individual and team assessment & feedback
- Selecting a PC-based simulation to demonstrate the ITS¡¦ ability to assess individual and team skills
- Developing a prototype and demonstrating the ability of the ITS to provide assessment and feedback to both individuals and the team as an entity for the small team-based training event described in Phase I, using the PC-based simulation described above
- Developing a prototype and demonstrating the ability of the ITS to provide assessment and feedback to both individuals and the team as an entity for players acting as a team in a massively multi-player game
- Evaluating any possible differences requiring additional research for various types of teams (e.g., infantry vice armor, staff vice operational, service-specific vice joint vice inter-agency vice coalition, battalion staff vice division staff, squad vice platoon vice brigade)
- Developing a detailed research report on lessons learned during this effort

The Phase II deliverables will be software which allows for demonstration of the ITS in the training event and a detailed research report as described above.

PHASE III: The company is expected to obtain funding from the private sector an/or non-SBIR government sources to develop the concept into a product for sale in the private sector and/or military markets. In Phase III, it is anticipated the successful bidder will be able to apply the same collaborative team-training techniques developed in Phases I & II to building a commercially-marketable ITS. Potential customers include all branches of the U.S. Armed Forces and law enforcement organizations at various levels. In addition, any organization that requires teams to operate together and can simulate the individual and team interactions via PC-based simulations would be a potential customer. Finally, game companies that host massive multi-player games over the Internet for entertainment purposes might be potential customers for the technology, as it would improve players¡¦ skills and make game play more entertaining.

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4) ¡§Infantry Situation Awareness¡¨, available at Army Research Institute¡¦s website, http://www.ari.army.mil
5) ¡§Command Group Training in the Objective Force¡¨, J.R. Gossman et. al., http://stinet.dtic.mil/cgi-bin/fulcrum_main.pl?database=ft_u2&searchid=0&keyfieldvalue=ADA406176&filename=%2Ffulcrum%2Fdata%2FTR_fulltext%2Fdoc%2FADA406176.pdf
6) ¡§Advanced Team Decision Making: A Model and Training Considerations¡¨, C. Zsambok, available at Army Research Institute¡¦s website, http://www.ari.army.mil
7. ¡§Review of Battle Staff Training Research at Brigade and Battalion Levels¡¨, B. Sterling, available at Army Research Institute¡¦s website, http://www.ari.army.mil
8) ¡§Team Training and Performance Research: A Ten Year Review¡¨, C. Bowers et. al., available at Army Research Institute¡¦s website, http://www.ari.army.mil
9) ¡§Methodology for Selecting Team Training Techniques¡¨, J. Kornell, available at Army Research Institute¡¦s website, http://www.ari.army.mil
10) ¡§Development of a Refined Staff Group Trainer¡¨, S. Quensel et. al., available at Army Research Institute¡¦s website, http://www.ari.army.mil

KEYWORDS: Intelligent tutoring systems, ITS, PC-based simulations, collaborative training, team training

A03-205 TITLE: Software Tools for Modeling Urban Details

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM OneSAF

OBJECTIVE: To develop an Urban Authoring Tool, which shall contain specialized tools for building urban features, including buildings, interiors and subterranean areas of interest.

DESCRIPTION: In recent years, several specialized, commercial computer automated design (CAD) tools have emerged for rapidly visualizing buildings, interior layouts, and landscapes. These range from consumer products for visualizing home improvements and interior designs, to tools for professional architects that include automated design of trusses, framing, and other components consistent with structural load and other engineering considerations. These software tools provide an efficient method for creating visually realistic environments, such as might be used in urban warfare, anti-terrorist, or peacekeeping training simulations. However, they do not provide the non-visual information that is required to support realistic interactions among computer-generated and human-controlled entities immersed into the synthetic environment.

What is needed are scenario composition tools, similar in their simplicity to these commercial design tools, that create simulation objects that include the non-visual attributes required for training simulations. These objects would include such attributes as material and surface characteristics, 3-D topological relationships, and other properties and relationships that can be represented in the Synthetic Environment Data Representation and Interchange Specification (SEDRIS), Data Interchange Format (DIF), and Compact Terrain Database (CTDB).

PHASE I: Research and document what is needed in tools to create correlated urban components in multiple formats including a visual representation and non visual details needed for computer generated forces. Using data requirements from high-performance urban synthetic Environment simulations, develop a concept design for an Urban Authoring Tool that can lower the cost and time required to create correlated urban environment databases for multiple users. Include a study of existing tools and software technologies that can help address an analyses of alternatives. Document the needed design, including example screen layouts, data representation model, and feature lists. Develop estimates of feasibility, development cost, and cost savings for urban environment creation.

PHASE II: Based on the design concepts developed in Phase I, create a prototype Urban Authoring Tool that demonstrates reduction in cost of urban terrain development. This software tool may be either an extension of an existing commercial tool, or a completely new development. The tool should import and export synthetic environments in the SEDRIS Transmittal Format (STF) or in formats readily converted to/from STF and other formats. Using the authoring tool, create a small urban environment, demonstrating cost and time savings.

PHASE III DUAL USE APPPLICATIONS: The authoring tool can find application to MOUT and other programs. It can also be used in commercial architectural visualization to create simulations of human traffic flow, etc.

REFERENCES:
1) Birkel/Janett Paper at Fall 02 Simulation Interoperability Workshop (SIW), www.sedris.org.

KEYWORDS: Database, SEDRIS, CTDB, Urban Terrain, Modeling, CAD

A03-206 TITLE: Common Aggregation Framework for Simulation Scalability

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO STRI - PM WARSIM - JSIMS Land

OBJECTIVE: To develop a common framework for aggregating and de-aggregating entities in constructive simulations. The framework should facilitate the interoperability between models at differing levels of fidelity, facilitate dynamic entity count depending upon system load, and facilitate preservation of key behaviors throughout the aggregation levels.

DESCRIPTION: Our growing desire to run large-scale simulations with hundreds of thousands of entities face practical barriers to graceful scaling, such as the hardwares inability to cost-effectively host the simulations. One promising approach is to aggregate entities by substituting resource intensive, high fidelity models, with more efficient and lower fidelity models, thus keeping the number of models to a minimum, regardless of the implied number of entities in the virtual world. Army Constructive simulations have achieved significant performance improvements by aggregating a number platforms into equipment groups. Many hurdles keep aggregation from becoming a widely used technique.

Integrating models with different levels of detail forces redevelopment and limits the diversity of models in a simulation. Consider the case of integrating the Air Forces simulation with the Army's aggregated simulation. Since the Air Forces models presume the ability to identify and target a single platform, there is difficulty in understanding and adapting to the Army's model where platforms are tracked in equipment groups and precise locations are derived. Today, model developers approach the world with the view that other models will work at the same level of detail or same level of aggregation. In the future, if a common framework exists, model developers will interact at varying levels of detail and at multiple-levels of resolution.

The purpose is to develop an aggregation framework that enables entity reduction, model interoperability, and behavior preservation. Entity reduction would improve performance and model interoperability would promote model reuse by giving models with differing levels of detail a standard scheme of interaction. Models that exhibit appropriate behavior, regardless of their level of aggregation, would preserve simulation validity.

PHASE I: Develop the architecture concept and the conceptual design of the common aggregation framework. Research in the following areas will be needed:

- Techniques for load-balancing of the simulation across platforms
- Aggregation and de-aggregation techniques for scalability
- Preserving simulation validity while working with models of varying levels of aggregation

Phase I will conclude with an analysis of the design detailing how the aggregation framework addresses interaction of models with differing level of details, aggregating and de-aggregating techniques for scalability and provide load-balancing capability.

PHASE II: Develop and test prototype of framework, producing a means for future simulations to incorporate aggregation. Proof of concept and demonstrate results of Phase I.
- Demonstrate interoperability between models at different levels of aggregation across domains.
- Demonstrate dynamic aggregation and de-aggregation depending upon system load.
- Demonstrate behavior preservation characteristics.

PHASE III: Commercial simulation based acquisition endeavors will better integrate engineering level models with system level models. For example, Artificial Intelligence (AI) computer games, and in the AI movie industry. Industry-wide model reuse should increase significantly. A successful aggregation framework would enhance the interoperability of DoD training simulations. Lowered entity counts would lower the cost of deploying training simulations to a large number of sites. The goal is to have a common framework so that models across domains will interact at varying levels of detail and at multiple-levels of resolution.

REFERENCES:
1) Aggregated Combat Models http://www.nps.navy.mil/orfacpag/resumePages/notes/aggregated.pdf
2) Operations Research Department, Naval Postgraduate School, Monterey, California, February 2000.
3) Reynolds, Natrajan, Srinivasan, 1997, Consistency maintenance in multiresolution simulation http://portal.acm.org/citation.cfm?id=259235&coll=portal&dl=ACM&CFID=5661420&CFTOKEN=79921065, 1997, ACM Press New York, NY, USA.
4) Peterson, G. D. "Animal Aggregation: Experimental simulation using vision-based behavioral rules" pages 623-630 in 1992 Lectures in complex systems, eds. L. Nadel and D. L. Stein. Reading, MA, Addison-Wesley. http://limnology.wisc.edu/peterson/PDF-myfiles/SFIflocking.pdf

KEYWORDS: aggregation, framework, simulation, scalability, model, de-aggregating, levels of detail, fidelity, load balancing, interoperability.

A03-207 TITLE: Multi-Resolution Terrain Models Representation

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: One SAF Program and RDEC Federation

OBJECTIVE: Increase representation, performance and consistency of model representation in distributed simulations.

DESCRIPTION: Increasing demands are being placed on Distributed Simulation Battle Labs to integrate models ranging from the engineering system component level through Unit of Employment (UoE) level. These models necessarily must operate at many levels of resolution. Real-time data, live and constructive entities, and simulations are beginning to link with each other in larger federates. Currently, there is no collaborative or single capability to rapidly represent or visualize multi-resolution models at varied levels with all necessary attributes to perform interoperable mission usage from the individual combatant to the joint commanders. Of particular interest and complexity is the representation of the synthetic terrain environment and how can we incorporate multi-resolution data (models, etc) into our dynamic simulations. There are many examples of these sort of multi-resolution simulation models (e.g., terrain, engineering, 3D-model etc.). The goal is not to focus on all of them but to increase the validity of the simulation by incorporating multiple models. So as a matter of presenting the problem, the focus example will be on terrain models; but this example is not to limit the scope of the research. Terrain that is represented at sub-meter resolutions for engineering and individual warfighter simulations must be aggregated into lower-resolution representations for simulations encompassing large unit force-on-force engagements. In addition, a wide variety of terrain "primitive" representations have evolved that are optimized for various simulation types, including Triangular Irregular Networks (TINs), gridded data, and thematic layers. This disparity in terrain representations has made it difficult to create a single, integrated "authoritative" terrain representation for distributed multi-modal simulations. In addition, the complexity of the necessary algorithms and the required computing power are a couple of the factors that shape the design and implementation of a simulation model. One approach that has been constantly considered to address this is issue is the creation of a Synthetic Environment server that provides terrain data (models) at requested resolutions, with specified attribution, and in specified formats to each simulation model. By no means is it implied that this is a homogenous solution to this problem, but a method that could significantly simplify the development, maintenance, and delivery of correlated multi-resolution data to simulation federates. Most importantly, by eliminating the need to create multiple, correlated databases for several applications, it could reduce the time to create or update the terrain environments. There are no collaborative analysis tools and methods, at the present time that is consistent with current command and control frameworks.

Phase I: Using the US army evaluation environment called Joint Virtual Battlespace (JVB) and the OneSAF simulation Product Line Architecture Framework (PLAF) as a reference, research candidate design approaches for representation of multi-resolution models. Research the methods, processes, and algorithms that the candidate approach requires. Develop a design analysis concept that interfaces/interoperates with current architecture (e.g., architecture interface, algorithm, framework, and collaborative/enterprise environment) that supports information flow, communications, situational awareness, weapons and survivability. At the same time the designed concept supports development of a wide family of new systems (Future Combat System) and others for sharing multi-resolution models in a collaborative environment.

PHASE II: Based on the design concepts developed in Phase I, create a prototype multi-resolution design concept (architecture component, plugging, interface, and design algorithm). The design concept must support existing and evolving simulation architectures providing the necessary fidelity, resolution without degrading functionality to support Internet collaboration for the individual and federate M&S components allowing them to be combined (interoperate) to meet the necessary functionality and fidelity of the intended application (analysis, experiment). Using a small, synthetic environment as an example, demonstrate the ability to access data in multiple formats, at varying resolutions, and with varying attribution. The prototype does not need to address the full range or potentially required models and services, but should demonstrate one or more effective multi-resolution modeling techniques that can simplify collaborative model design, and increasing the communication of heterogeneous environment comprised of distributed simulations software while reducing run-time computational load.

PHASE III: Develop and market the design to military and civilian organizations in a dual use faction: The multi-resolution Synthetic Environment Design could find application in urban planning or emergency preparedness.

REFERENCES:
OneSAF
1) Butler, B., "Design Strategies for Multi-Resolution Synthetic Environment Representations with Examples from OneSAF SNE", (02-SIW-087), Proceedings of the Fall 2002 Simulation Interoperability Workshop, September 2002.

2) D. Miller, et al., “An Environmental Data Model for the OneSAF Objective System”, (02-SIW-082), Proceedings of the fall 2002 Simulation Interoperability Workshop, September 2002.
3) Joint Virtual Battlespace (JVB) – A Concept Evaluation Environment
Dr. Rob Alexander, SAIC, 1100 N. Glebe Road, Arlington, VA 22201. (703) 907-2547; ralexander@sito.saic.com
4) SISO Product Nomination (PN) – “Base Object Model (BOM) Specification”, Simulation Interoperability Standards Organization (SISO), November 2002.
5) Steve Reichenthal, “The Simulation Reference Markup Language (SRML): A Foundation for Representing BOMs and Supporting Reuse”, 02F-SIW-038, 2002 Fall Simulation Interoperability Workshop (SIW), September 2002.
6) Dr. Andreas Tolk, “Avoiding Another Green Elephant - A Proposal for the Next Generation HLA Based on the Model Driven Architecture”, 02F-SIW-004, 2002 Fall Simulation Interoperability Workshop (SIW), September 2002.
7) Draft Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP) Mode, Draft 4, Simulation Interoperability Standards Organization (SISO), 3 June 2002.
8) P. Gustavson, L. Root, S. Goss, J. Bachman, M. McAuliffe, “CODE-Net: XML, SOAP and Simulation Development”, 02S-SIW-111, 2002 Spring Simulation Interoperability Workshop (SIW), March 2002, http://www.simventions.com/whitepapers/02S-SIW-111.htm
9) BOM Study Group, "BOM Methodology Strawman (BMS) Specification", SISO Reference Product, Version 0.7, 15 May 2001, http://simventions.com/boms/BMS_0_7.htm.

KEYWORDS: Advanced Colloborative Environment, Distributed Interactive Simualiton (DIS), Future Combat System (FCS), Joint Virtual Battlespace (JVB), OneSAF Product Line Architecture Framework (PLAF), BOM, FOM, HLA, Component Architecture, Multi-Resolution Models, Modular Architecture, SAF, Network Colloborative Environment, RDEC Federation, XML, X3D

A03-208 TITLE: Increased Plastic Oxygen/Water Barriers

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems

OBJECTIVE: The objective of this SBIR is the development of optical quality plastics with increased oxygen/water barriers for the replacement of glass. The plastic alternative should be highly durable in military environments including diesel fuel, salt fog, and temperature extremes. Additionally, an inherent weight savings should be associated with the plastic alternative.

DESCRIPTION: The Army?s Future Combat System (FCS) has an extremely aggressive weight reduction goal in order that it may achieve its aim of flying light. To meet the survivability and durability objectives of the program, light weight yet durable plastics are going to have to play a critical role. One of the most challenging areas will be in components that need to have good or exceptional optical quality in addition to this durability. Currently, candidate plastics are still sensitive to environmental factors including oxygen and water degradation. Unfortunately, exposure to oxygen and water severely limits the functionality and life of critical sensors and electronic components. To improve life-cycle costs, it is necessary to find a cost efficient way to protect the systems essential to the survivability of military personnel.

A light-weight, high impact plastic with good optical density and low permeability is required for advancing the technology available for Identification, Friend-or-Foe (IFF) for the Future Combat Systems. In addition, a recently proposed system of long lasting, highly efficient organic LEDs will not be possible without a substantially improved plastic. With the optical density available by many plastics already in production, in conjunction with increased environmental barriers, these plastics can also be incorporated into a wide range of other applications, such as sensors, lenses and vision blocks. The increased properties of improved lifespan and durability will advance the current systems of FCS and aid in the ability to achieve FCS weight limits without compromising other critical technologies such as mobility and armor.

PHASE I: The contractor shall research methodologies for the development of plastics with good optical density and increased oxygen/water barriers to exceed those available in commercial plastics. This phase will identify the current state of the technology and designate reasonable goals for such a program. The research effort should focus on developing methodologies for maintaining the integrity of the material throughout the variety of environmental conditions likely to be faced under military operations.

PHASE II: The contractor shall utilize the goals and methodologies from Phase I to develop and provide samples, in a variety of shapes, to be tested. The tests should be conducted to demonstrate both a decrease in permeation as well as the ruggedness of the plastic alternative. Military Standards, in particular MIL-STD-810, should be explored as a guide for demonstrating the durability of the plastic.

PHASE III DUAL USE APPLICATIONS: Development of plastics with oxygen/water barriers will allow for applications in automotive and medical industries, as well as in commercial instrumentation (outdoor camera/surveillance equipment) that is used in difficult environments over a period of time.

REFERENCES:
1) OXYGEN PERMEATION INTO BARRIER PLASTIC PACKAGES AS INFLUENCED BY WATER SENSITIVITY (http://www.confex.com/ift/98annual/accepted/397.htm)
2) Permeation: Its Effects on Teflon (http://www.semiconductorfabtech.com/journals/edition.11/download/ft11-4_03.pdf)
3) MIL-STD-810

KEYWORDS: Plastic, Oxygen/Water Barrier, FCS

A03-209 TITLE: Lightweight Multi-Use Slipring

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM BFVS

OBJECTIVE: This R&D effort is to design and build a slipring that is lighter in weight and occupies less volume while providing greater performance than sliprings available in current ground combat vehicles. The slipring should be capable of integrating fiber optic technology with its inherent weight savings and capability for greater data transmission rates through the slipring. The slipring should also be capable of distributing power as well as data and should be compatable with Future Combat System (FCS) requirements.

DESCRIPTION: Many embedded applications involving computing and data communications need design flexibility that can cope with system upgrades, changing user requirements, changing protocols, etc. A lightweight slipring can provide this flexibility for ground combat systems design and support novel implementation approaches leading to performance improvements, reduction of the system's cost, and reduction of the power consumption. A lightweight slipring can also be a significant aid in satisfying the C-130 transport requirement for the FCS.

The FCS slipring performance requirements are as follows:

The slipring must be capable of continuous 360 degree rotation in either direction without any limitations. The slipring must be capable of passing both electrical and fiber optic signals in multiple quantities. The slipring must be capable of passing high speed digital data through standard interfaces such as Ethernet, Fiber Channel, FireWire, and Universal Serial Bus. The slipring must be capable of passing both analog and digital video signals in multiple quantities. The slipring must be capable of passing high voltage/high current electrical signals (e.g. 28VDC, 120VAC, 600VDC) that provide electrical power to/from other vehicle subsystems. The slipring must also be capable of passing non-electrical/non-electronic items such as pneumatics (air), hydroulics, and water.

The size and weight of the slipring must be tailorable such that it can be utilized in both manned and unmanned FCS ground vehicles and must be consistent with FCS overall vehicle weight and transport requirements. The slipring must be packaged in a ruggidized manner suitable for US Army wheeled and tracked ground vehicles.

Current slipring technology is limited in terms of performance (data rate and quantity) when passing high speed digital interfaces using either electrical or fiber optic signals. Current slipring technology is often physically large and very heavy in weight.

This SBIR should investigate the following:

1. Study and identify the digital and power components used in existing Vetronics systems that need to communicate through a slipring.
2. Design multi-use interface to meet requirement defined in 1.
3. Investigate and design at least 50% lighter slipring to transmit power, video, and data.
3. Test the lightweight slipring on the electronic vehicle system and evaluate its functionality and performance.

PHASE I: The contractor shall research, design, and develop a prototype lightweight multi-use slipring. The slipring must be capable of distributing power and large amounts of video, sensor and other communication data between vehicle hull systems and turret systems.

PHASE II: The contractor shall extend the research and development of the slipring from Phase I into a working production quality slipring. Tests should be conducted to demonstrate the ruggedness and data throughput. Emphasis shall be on size, weight, and reliability of data transmission.

PHASE III DUAL USE APPLICATIONS: The system developed above in the description can be used in military and civilian applications. For potential commercial applications, research shall be conducted for implementation into mobile systems that require transmission of power and large amounts of data between rotating sections. Research also shall be conducted for implementation into the Future Combat Systems (FCS) mission. This slipring could be used in radar applications or for aircraft sensor suites such as AWACs or Unmanned Aerial Vehicles (UAVs).

REFERENCES:
1) Fibre Optic Rotary Joints: Product Overview, Focal Technologies Inc., www.focaltech.ns.ca
2) Technical Bulletin: Digital Data and Video Signals through Slip Rings, Glenn Dorsey, Director of Engineering, Electro-Tec Corporation, Blacksburg, Virginia.
3) HIGH SPEED DATA LINK (HSDL), Electro-Tec Corp., A Kaydon Company, Ann Arbor, Michigan, 540-552-2111.

KEYWORDS: slipring, turret, Future Combat System, hardware component upgrade, weight saving, space saving, size reduction, vetronics, rotating sections

A03-210 TITLE: Damage-Based, Low-Threshold Optical Attenuating Materials

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: Program Excecutive Officer, Ground Combat Systems

OBJECTIVE: To develop two classes of materials for use in laser protection applications: a light-activated instant-blackening optical material, and a low damage threshold lambertian scattering optical material.

DESCRIPTION: In order to protect soldiers' eyes and other military sensors from potentially harmful laser radiation in the visible spectrum, it is necessary to develop materials which respond very quickly (in under a nanosecond) to block the transmission of harmful laser energy through optical systems. Materials research is key to achieving this goal. This topic solicits materials research to develop two classes of optical materials.

First, a material research effort is sought for the development of a low damage threshold optical material that exhibits lambertian scattering upon damage. All optical materials damage if light of high enough intensity is focused into them, particularly near interfaces. Many current optical materials (i.e., glasses, optical acrylics, etc.) exhibit somewhat directional scattering upon optical damage. Optical materials that minimize the directionality of light scattered at the moment of optical damage and spread the scattered light in a lambertian pattern would be advantageous. The developed materials should damage at a much lower energy density threshold than common optical materials, such as normal window glass and optical acrylics, and when the material damages, it should scatter light over a very wide angle in an approximately lambertian pattern.

Second, a material research effort for the development of a light-activated instant-blackening optical material (solid, liquid, or gas) is sought. The material will most likely be incorporated into optical systems at an intermediate focal plane. The material should have a high visible transmission under normal daylight illumination conditions (at least 50% transmissive throughout the visible spectrum) and in general be of good enough optical quality for inclusion in optical imaging systems (i.e., low haze, etc.). When exposed to high intensity light (such as a laser pulse), the material should blacken instantly (in less than one nanosecond) and prevent the light from being transmitted through the optical system to the eye or sensor. The degree of darkening should provide enough optical density to protect the retina against common Class 4 laboratory lasers. Emphasis upon materials that blacken via damage mechanisms (i.e., sacrificial materials) is desired. However, materials whose blackening is reversible will be considered. Both transmissive and reflective materials that exhibit blackening under high intensities will be considered.

PHASE I: Research and study several candidate material systems for either or both classes of optical materials described above. Conduct detailed theoretical analyses and performance predictions of the material systems investigated and provide detailed rationale for the material systems chosen for investigation. Small-scale sample preparation, experimentation, and material performance characterization is highly encouraged. Analyze and summarize theoretical and experimental results.

PHASE II: Develop processes and produce prototype optical materials (in sizes and shapes appropriate for incorporation into complex optical vision system designs) for either or both classes of optical materials described above and test their optical performance and their properties under high-intensity focused laser irradiation. Refine the manufacturing processes to produce improved materials with better properties both under normal optical (daylight) illumination and under laser irradiation.

PHASE III DUAL USE APPLICATIONS: Military laser safety devices (for eyes and sensors), laboratory and medical laser safety devices/eyewear, optical data storage (three dimensional), compact disks, DVDs, three-dimensional holographic host materials, hidden security identifiers

REFERENCES:
1) Laser Focus World, June 2000, Center for Research and Education in Optics and Lasers, University of Central Florida (Note: This reference is listed only as a generic introduction to the problem of laser protection. Technologies proposed for this SBIR should be new and innovative ideas.)

KEYWORDS: optical, substrate, laser, lambertian, optical attenuation, scattering, absorption, optical damage

A03-211 TITLE: Low Cost Materials, Designs, and Manufacturing Processes for Robust Tubular Solid Oxide Fuel Cells (SOFC)

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM MEDIUM TACTICAL VEHICLES

OBJECTIVE: The objective of this project is to identify materials, designs, and manufacturing processes for mechanically and chemically robust tubular solid oxide fuel cells (SOFC) for use as the propulsion system for heavy vehicles. The fuel cell propulsion system is intended to physically fit in the space available for a current diesel engine. Development of high-performance SOFC, using low-cost materials and manufacturing processes, is needed to produce commercially viable fuel cells. Cell designs must be able to withstand the vibration and shock typically found in heavy duty trucks. The materials and manufacturing methods selected to produce low cost tubes must maintain high performance output for the application. Characterization of the mechanical strength, toughness, electrical performance, and electrochemical performance will assure that the tube material, design, and manufacturing processes are optimized.

DESCRIPTION: Fuel cell technology has the potential to dramatically increase the performance of many military vehicles, including armored personnel carriers, tracked vehicles and heavy trucks. Fuel cell based propulsion systems can reduce the fuel usage of the Army fleet and reduce the cost associated with supplying fuel to the battlefield for Army ground forces. Fuel cell systems will also reduce the noise and the heat signature for reconnaissance vehicles and other forward operations. SOFC stacks/bundles for military vehicles must be mechanically robust and suited for use with the Army standard fuel, JP-8. At the same time, the SOFC propulsion systems must retain high fuel efficiency and be cost-competitive with internal combustion engines. A development and demonstration project for a tubular SOFC-based heavy truck engine has been initiated, but opportunities must be explored for materials and manufacturing optimization. The cost and mechanical properties of SOFC tubes needs to be thoroughly investigated and documented, while exploring the lowest cost materials and processing techniques that give the highest performance and efficiency. Optimizing the design and manufacturing of the tubes will allow widespread utilization of these solid oxide fuel cells.

PHASE I: Contractor shall research multiple data sources and conduct a study to identify the best materials to provide cost-effective, high performance tubular SOFC designs for the Army applications described above. Particular areas of interest include the mechanical ruggedness, material costs, and manufacturing costs of the air electrode tube and the fuel electrode. Manufacturing costs while not the primary focus of Phase I, must not be ignored in the materials selection process. Metrics for assessing mechanical/chemical robustness and electrochemical performance will be established. The study will include a plan to demonstrate and validate the performance of the best material(s) to provide the most cost-effective solid oxide fuel cell. A final report will be written to reflect an outcome of the study.

PHASE II: Advanced manufacturing techniques and processes will be developed for the production of cost-effective SOFC tubes utilizing the materials and designs studied and selected in Phase I. Methods developed will assure consistent high quality and high performance tubes, while keeping the production costs low. The potential use of these tubes will be in bundles for the Turbo Fuel Cell Engine that will fit into the space-claim for an engine and related components in a typical military/commercial class 8 tractor. Performance of the tubular cells manufactured by these processes will be demonstrated and documented. A final report recommending the cost-effective large scale manufacturing processes of SOFC tubes will be an outcome of the Phase II efforts.

PHASE III DUAL USE APPLICATIONS: In addition to military applications, the tubular SOFC bundles, developed in this program, will be applicable to a wide range of commercial vehicles, including buses, commercial trucks, construction and farm equipment. The materials and manufacturing processes developed in the program will be commercialized for use in both mobile and stationary SOFC platforms.

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1) Singhal, S.C., Recent progress in tubular solid oxide fuel cell technology, International symposium on solid oxide fuel cells, Aachen (Germany), Report No. DOE/MC/28055--97/C0840; CONF-9706108--, Jun 1997.
2) Veyo, S. E.; Dowdy, T. E., Fuel Cell Power Plant Initiative. Volume II: Preliminary
Design of a Fixed-Base LFP/SOFC Power System, Defense Technical Information Center, http://stinet.dtic.mil, 20 Mar 2002
3) S. C. Singhal, "Advances in Tubular Solid Oxide Fuel Cell Technology," Proceedings of the 4th International Symposium on Solid Oxide Fuel Cells, Pennington, N.J. , Vol 95-1, 195-207 (1995)
4) W. L. Lundberg, "Solid Oxide Fuel Cell/GasTurbine Power Plant Cycles and Performance Estimates," Power-Gen International '96, Orlando, FL, Dec. 4-6, 1996
5) Mark C. Williams, Redesigned All-Ceramic Fuel Cell Exceeds Targets,
Developer Now Gearing Up for Final Phase of R&D, US Dept of Energy DOE Techline, April 22, 1996.

KEYWORDS: fuel cells , SOFC, electrochemical, tubes, fuel efficiency, materials

A03-212 TITLE: Hydraulic Actuated Roll Inhibited Active Suspension for the Army

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, Light Tactical Vehicless

OBJECTIVE: To improve the current suspension systems within the Army's fleet of vehicles with a technological solution that will enhance on/off road performance that will assure the future tactical vehicles will be able to safely keep up with the objective force movements.

DESCRIPTION: Current suspension technologies, such as hydraulic, pneumatic, as well as air bag systems, are trying to resolve unfavorable instability in vehicles within commercial applications. These types of technologies don't exist on military production vehicles but some derivative of these emerging technologies could significantly impact performance in a positive manner. The future system(s) will enhance the safety of occupants in the crew compartment by reducing the amount of absorbed energy into the tactical vehicles. Suspension system should decrease the amount of energy absorption during off road operations, which will increase the reliability and prolong the life of the vehicle. It will also reduce dangerous conditions of vehicle roll by stabilizing the entire vehicle based on terrain conditions and load leveling. The specific requirements for such a system should include user defined capabilities and stability in changing within its heights and loading conditions. Recent ongoing research within the industry is identifying the need for controlled maneuvering on off-road terrain and adverse environments.

Several concerns lay within the control area of the system. Enhanced, electronically controlled or mechanically sensored systems bring about new technological advances. Such a system will prohibit the vehicle from rolling over during critical maneuvers. This program seeks to provide the Army with an active/semi-active suspension system to further advance the capabilities of off-road terrain vehicles. The selected proposal should fit within the current suspension envelope so as to prevent significant geometry changes in the body and chassis. A production cost increase over the existing system in the tactical vehicle is predicted, but the selected proposal should consider future production cost delta as a significant parameter.

PHASE I: Research current suspension technologies available within the commercial market. Perform feasibility study and analyze/compare the results of the research as applicable to actual military systems. At the completion of Phase I, submit a final report, which shall provide a recommended technology to be further researched, and planned for development and implementation. Also, propose a selection of military vehicle platform(s) for the given suspension technology. The final report will provide results of any modeling and simulation efforts to sustain a successful R&C program for the recommended technological solution for the selected vehicle platform.

PHASE II: Design, develop and install the proposed suspension technology on the selected military vehicle platform(s). Build a prototype demonstrator and provide an update on demonstrator's progress every 6 months. The progress status should include any failures and modifications required for Phase II completion. A final report shall be completed and submitted at the completion of Phase II along with the prototype demonstrator. The final report should also include all progress reports and all testing performed during Phase II, along with commercialization plan and projected production costs for this technology.

PHASE III DUAL USE APPLICATIONS: The suspension system could eventually be re-packaged for use on a wide range of military vehicle fleets as well as a large range of civilian vehicles. Commercial applications could include various sizes of vehicles with light to heavy payload capabilities but with off-road missions as part of its operating scenarios.

REFERENCES:
1) http://www.tacom.army.mil/tardec/nac/combatt.htm
2) http://www.off-road.com/ford/news/2002_10/military/
3) http://www.fas.org/man/dod-101/sys/land/m998.htm
4) http://www.ssss.com/fmtv/specpdf.asp
5) http://155.148.74.235/ITEA/itea99/testMS/fol11/pap.pdf

KEYWORDS: Active Suspension, semi-active suspension, vehicle roll, tactical vehicles, load-leveling, energy absorption

A03-213 TITLE: Biofiber-Reinforced Structural Composites for Use in Matting/Temporary Roadway Panels

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Bridging

OBJECTIVE: The objective of this SBIR is to develop a capability of using biodegradable lightweight composite materials in the Objective Force. Production of lighter biodegradable systems is possible with new emerging technology. By replacing heavy metal components with lighter biodegradable structural composites the Army may benefit from being able to deploy systems faster and farther, build them more economically, and fabricate matting/temporary roadway panels in remote areas using local materials that will compost in place after service.

Military Bridging sites are typically challenged with poor access/egress conditions. Slick, muddy, conditions routinely impede the flow of vehicle traffic across the deployed bridges. Other potential usage could include soil stabilization for helipads, landing mats, expedient roadways and runways, and Joint Logistics Over the Shore applications.

DESCRIPTION: In the initial study, biodegradable composites will be prepared with structural characteristics required for matting/roadway panels. Of particular interest to the Army is identification of a material system that can be used to assist military vehicles in climbing muddy inclines after a bridge crossing. The types of materials that will be targeted include composites tailored for structural strength and high load that will be based on lightweight natural fillers and reinforcements including but not limited to agricultural products that may be available at remote locations. Incorporated in the tailored composites will be requirement for the system to work in a wide variety of soil conditions. The topic will be coordinated with the US Army Corps of Engineers Waterways Experimental Station, US Army Natick Laboratory and PM Bridging.

PHASE I: During the first phase of this program the contractor will investigate a suitable composite material for matting/roadway panels. This project will investigate the role biofibers could play in developing lightweight biodegradable panels. Areas of study for this project include, but shall not be limited to: resin systems that can be used in conjunction with biofibers, available forms of reinforcement (single fiber, fiber tow, woven textiles, braiding, preforms, etc.), durability and strength of the material system. The potential material candidates shall be subjected to a proof of principal testing to arrive at top candidates. Tests that will provide the exit criteria for this determination will be performed on prototypes and include, but are not limited to: degradation and stabilization studies, structural-properties of candidate designs, hydrophilic/hydrophobic, heat resistant/flammability, biodegradable properties, and traction properties.

PHASE II: During the second phase of this program the contractor will design, fabricate and test top candidate solutions from Phase I. Top three candidate materials shall be fabricated to 12 foot by 60 foot span for field testing. Effects of prolonged exposure to heat and moisture shall be evaluated in a field test. 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.

PHASE III DUAL USE APPLICATIONS: During the third phase the solution candidates can be used in a broad range of civilian and military applications including any and all of the possibilities listed below: 1) Housing Industry: structural drywall and insulation panels; 2) Construction: road stabilization, Road side: sound barriers; 3) Agricultural and Industrial structures: example: chicken houses on farms, barns, etc.; 4) Temporary Shelters for people in disaster struck areas or for soldiers.

REFERENCES:

1) “Polyurethane foam composites for grower applications and related methods,” U.S. Patent No. 6,479,433; 2002.
2) “Polyurethane Elastoplastics for Load Bearing Applications.” October 13-16, 2002. Proceedings of the API Polyurethane Conference 2002, Salt Lake City, Utah, p.p. 307-315.
3) "Solids produced from ash and process for producing the same," U.S. Pat. No. 6,180,192; 2001.
4) "Extrusion Close-Up - Die Drawing Makes 'Plastic Steel' from Wood-Filled PP", Editor Jan Schut, Platics Technology Online Article, March 2001 (www.plasticstechnology.com).
5) Sachs, H. I., "Bonding of Forest and Agricultural Products," in Polyurethane Handbook, 1985, Edited by Gunter Oertel, Hanser Publishers, New York, pages 564-570.
6) "Method for Compression Molding Articles from Lignocellulosic Materials,"U.S. Pat. No. 5,002,713; 1991.

KEYWORDS: biofibers, biodegradable, economical, lightweight, bridging, composites, structures, objective force, matting, temporary roadway, remote area, local agricultural material, compost, access, egress, landing mats, runways, soil stabilization, natural fibers, shelters, housing, insulation.

A03-214 TITLE: Portable Highly Mobile Autonomous Robot for Mine Detection

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, FCS

OBJECTIVE: Development of small autonomous mobile robot technology for the performance improvement of mine detection for a given area. Specific areas of concern are portability, navigation and mobility, control, possible multi- agent cooperation, and the ability to interface to a mine detection sensor suite.

DESCRIPTION: In today’s battlefield, anti-personnel mines are a problem especially for an advanced “rapid deployment” force. The objective is to develop a portable autonomous platform capable to be delivered by an individual soldier or a small team of soldiers, and be able to sweep and detect a given approximate incremental area up to 90,000 sq. ft. Careful emphasis must be made on path planning and mobility, and their direct relationship with mine detection sensor suite, to accurately provide coverage to the given “off-road” area. A combination of GPS/INS and external (e.g., laser, sonar, etc.) sensor packages shall be integrated to offer potential solutions for path planning and mobility algorithm development. Other emphasis must be made on the development of probabilistic map of potential mine locations, based on the sweep, to assist the soldier(s) in determining alternatives for safe passage.

PHASE I: The contractor shall research and design a portable lightweight robotic system which can autonomously maneuver itself in a rapid uniform controlled pattern to sweep for mines for a given “off-road” area in increments up to 90,000 sq. ft. Emphasis shall be made on path planning, mobility, control, and interface to a mine detection sensor suite. Additional emphasis must be made on the creation of a computational tool (hardware and software) to assist an individual soldier or small team of soldiers to develop necessary alternatives to navigate the “swept” area. Feasibility of design shall be proven using modeling and simulation.

PHASE II: The contractor shall use results of the research efforts, develop a robotic system and extend the research and development of the system from Phase I into a working prototype which can be easily implemented by an individual or small team of soldiers. Tests shall be conducted to demonstrate the accuracy, robustness, and mobility performance of the system in a mockup realistic scenario using an actual team of soldiers. Additional emphasis shall be made on the soldier(s) ability to use this system to determine alternatives for save passage through a mockup mine field.

PHASE III DUAL USE APPLICATIONS: The system developed above in the description can be used in a broad range of military and civilian applications. For potential commercial applications, research shall be conducted for implementation into mobile robot security systems and mobile robot rescue and recovery systems. Research also shall be conducted for implementation into the Future Combat Systems (FCS) mission.

REFERENCES:

1) http://bsing.ing.unibs.it/~cassinis/minerobots_archive/art3.htm
2) http://voronoi.sbp.ri.cmu.edu/projects/prj_demin.html
3) Additional information can be obtained form the proceedings of the SPIE AeroSense Conference (Robot Mobility Session; Detection and Remediation Technologies for Mine and Minelike Targets Session), Mine Warfare Conference.

KEYWORDS: Lightweight autonomous/semi-autonomous mobile robots, mobility, probabilistic mine detection maps.

A03-215 TITLE: Enhanced Mobility for Small Vehicle Platforms

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: Physical Security (PM-PSE)

OBJECTIVE: This program will develop mobility platform components and subsystems for small, vehicle platforms weighing less than 1200 lbs. A primary emphasis will also be on soldier portable unmanned ground vehicles (UGVs) weighing less than 100 lbs.

DESCRIPTION: We require new and innovative technology enhancements for intelligent mobile platforms. These mechanisms can be improvements to existing wheel, track or hybrid wheel/track systems. They can also involve entirely new concepts in legged or other bio-inspired mobility running gear mechanisms. The state-of-the-art ground vehicle running gear technology is advancing rapidly in the age of computer control, advanced sensors and hybrid electric propulsion. However, a number of deficiencies still remain, which severely limit performance for obstacle negotiation and soft soil conditions. Smaller ground vehicle systems have an inherent disadvantage relative the larger, legacy vehicles: the world looks much larger and more difficult to traverse from their perspective. Several DARPA programs are addressing novel mobility platforms with gross vehicle weights of 600 kg and larger. TARDEC is actively engaged in developing research and manufacturing prototypes, which weigh less than 50 kg and are used for physical security and force protection applications. Current unmanned ground vehicle (UGV) design strategies in this size and weight category are severely limited by their mobility performance. The primary metrics for assessing platform performance are size, weight, complexity, cost, obstacle negotiation and soft soil performance.

Research in this topic includes:

(1) System design of innovative running gear mechanism for small UGV systems
(2) Individual mobility component design and testing relative to baseline technology
(3) Improved man/machine interface methodology for teleoperation, semi-autonomous or fully autonomous control of complex platform maneuvers
(4) Integration of mobility sensor configurations for situational awareness, platform control and path planning/navigation of prototype UGV systems
(5) Demonstrations of enhanced mobility through modeling and simulation
(6) Development of advanced prototype components and subsystems for User evaluation and testing

PHASE I: The first phase involves a preliminary design and feasibility analysis of novel running gear configurations for small UGV systems. The design validation shall include a hardware demonstration and/or extensive modeling and simulation to verify the Phase II prototype performance characteristics. Documentation of the engineering analysis shall be required in the final report.

PHASE II: The second phase consists of a final design, system integration and full implementation of a working prototype. This phase will conclude with a demonstration of the prototype system on a realistic test course, where enhancements to the obstacle negotiation and soft soil performance shall be verified. Deliverables in this phase 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: Phase III military applications include physical security and force protection. Phase III commercial applications include search and rescue, industrial inspection, and remote security operations.

REFERENCES:

1) "Unmanned Ground Vehicle Technology III," SPIE Proc. 4364, Orlando, FL (2001).
2) "Unmanned Ground Vehicle Technology IV," SPIE Proc. 4715, Orlando, FL (2002).
3)"Rapid Infusion of Army Robotic Technology for Force Protection and Homeland Defense," Proceedings of the Robotics session, Army Science Conference, Orlando, FL December 2002.
4) "Military Vehicle Technology Conference, SAE Symposium, Detroit, MI March 2003.


KEYWORDS: mobility, running gear, maneuverability, agility, controls, obstacle negotiation

A03-216 TITLE: Command and Control of Small Tele-Operated Robots

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: Physical Security (PM-PSE)

OBJECTIVE: The objective of this project is to research and develop technologies for the command and control of small tele-operated robots, such as would be used in inspection tasks, search and rescue operations, physical security, or police or military reconnaissance. The two main thrust areas are improving robot vision and exploring issues with multi-robot control.

DESCRIPTION: The state-of-the-art in tele-operated robotics is developing rapidly. However, there exist a number of deficiencies in current unmanned ground vehicle platforms. One area that is lacking is vision, where the quality of the camera systems and the availability of active lighting and image processing are limited. There are two scenarios of interest in this topic, the first of which is the operation of a single robot. This is typical in situations where the operator needs full concentration on the viewing screen, such as in inspection tasks or when operating in the difficult terrain that can occur in reconnaissance or search and rescue operations. The focus in this case is on improvements to existing camera/viewing systems. We are interested in a small camera system that has the following features: low power, wireless communication, user-controlled active lighting, automated and/or user-controlled image enhancement, wide field of view for navigation, narrow field of view for close-up inspection. The second scenario is where control of multiple robots is useful, such as reconnaissance over a large area in benign conditions or where the environment is well known, such as physical security applications in a warehouse or at a military installation. Issues here include: controlling multiple robots, determining the level of robot autonomy required, switching between the cameras of multiple robots, vehicle self-localization, top-down map-based view of vehicle locations and manual correction of GPS/INS using landmarks. The developed system should fit on a robot that is 50 Kg or less.

Research tasks in this topic include:
(1) Determine where to perform image enhancement: on the camera, on the robot or in the user interface
(2) Determine whether to use analog or digital communications
(3) Investigate solutions for user-controlled active lighting
(4) Determine whether a discrete or continuous optical zoom is best in terms of reliability, affordability and usability
(5) Investigate user-controlled image enhancement techniques, such as local histogram equalization or simple contrast stretching
(6) Investigate automatic and reliable image enhancement techniques, such as edge sharpening and denoising
(7) Investigate switching between different cameras on multiple robots
(8) Investigate the control of multiple robots (how much autonomy is required?)
(9) Investigate communications issues with controlling multiple robots
(10) Investigate robot self-localization issues

(11) Investigate implementation of manual landmark recognition
(12) Investigate robot control through touch-screen interaction
(13) Research human factors issues such as placement and functionality of controls for operating the robots, adjusting the lights and cameras, and switching between camera views
(14) Investigate form factor issues, such as size of the control unit and size and style of the viewing screen

The contractor is not expected to implement all of the above tasks, but should choose a reasonable subset that will provide a good working system for one of the two scenarios. Proposals for the single robot scenario should place more emphasis on the camera/viewing system, while proposals for multiple robot control should focus more on integration and human factors issues.

PHASE I: The first phase involves choosing the scenario of interest, determining appropriate research tasks, and performing the preliminary design of the hardware and software. The design should emphasize reliability and performance. Feasibility of the design shall be shown by either demonstrating or simulating key components of the system. Documentation of the design tradeoffs and feasibility analysis shall be required in the final report.

PHASE II: The second phase consists of a final design and full implementation of the system. The feasibility of the final design shall be shown by demonstrating or simulating all components of the system. All components shall be integrated and assembled into a prototype system. At the end of the contract, the prototype system shall be integrated with one or more robotic vehicles, as appropriate, 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: Phase III military applications include reconnaissance and physical security. Phase III commercial applications include search and rescue, industrial inspection, and remote security operations.

REFERENCES:
1)"Unmanned Ground Vehicle Technology III," SPIE Proc. 4364, Orlando, FL (2001). 2)"Unmanned Ground Vehicle Technology IV," SPIE Proc. 4715, Orlando, FL (2002).
3) www.cohu-cameras.com/products/mVisCams.htm
4) www.vision-control.com/code22/light/ei_light.htm
5) vrai-group.epfl.ch/projects/ati/pdadriver/
6) www.ncart.scs.ryerson.ca/NCART/PUBLIS/IC02.pdf
7) news.zdnet.co.uk/story/0,,t298-s2122734,00.html (GPS chip for PDA).
8) www-users.cs.umn.edu/~hougen/aaai2000.pdf

KEYWORDS: human supervisory perception, robotics, teleoperation, cameras, optics, image processing, handheld computer

A03-217 TITLE: Advanced Thermal Management of LEDs

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Future Combat Systems

OBJECTIVE: Develop LED packaging and interface technologies that would minimize the thermal resistance of LEDs while at the same time increase LED durability and lower total product cost.

DESCRIPTION: LEDs are quickly replacing incandescent lamps for many applications because of their tenfold increase in luminous efficacy, robust construction, longer service life, lighter weight, and the wide variety of wavelengths available. In particular, LEDs have jumped to the forefront in lighting applications such as traffic lights, pedestrian signals and tail lights in vehicles. The military has also begun to investigate the advantage of LEDs in Identification, Friend or Foe (IFF), near infra-red illuminator/search lights, and covert communication.

Unfortunately, the life and luminous efficacy is bounded by the junction temperature of the LED, therefore limiting their functionality. Elevated temperatures, as is common with vehicular and outdoor applications, can reduce the life of high performance LEDs from the rated 100,000 hours of service to less than 5,000 hours. Empirical data shows that for every 17 degree C rise in LED junction temperature, service life is decreased by one half. However, if the luminous intensity versus the junction temperature can be characterized and monitored, and the temperature rise controlled, the lifetime of the LED would be greatly extended.

Optimally, the LEDs would be characterized by measuring the radiation angle, maximum output vs. current and thermal resistance before being placed in an array. This determination would allow for correct placement of LEDs in the array. Additionally, continuous monitoring of the junction temperature would result in an essentially constant luminous intensity throughout the life of the LED. Monitoring the junction temperature would also enable the user to determine the remaining life of the LED. The technology to monitor the junction temperature is limited and as of yet, still very costly. An innovative design for continuous monitoring of the junction temperature would greatly improve lifetime and therefore the life-cycle costs in future IFF and covert communication systems.

PHASE I: The contractor shall research methodologies for continuous monitoring of LED junction temperatures. This phase will identify the current state of technology and designate reasonable goals for such a program.

PHASE II: The contractor shall utilize the goals and methodologies from Phase I to design a computer driven instrumentation system to measure the thermal characteristics of LEDs. Fabricate and test sample low thermal resistance LEDs for durability under various environmental conditions. Design tooling and produce production prototypes of these low thermal resistance LEDs and the low thermal resistance interface for mounting the LEDs.

PHASE III: A highly efficient LED allows for immediate commercial use. Some applications such as stop lights have already been converted to LEDs because of the lower incurred life cycle costs. A highly efficient, thermally optimized LED and ancillary mounting system could be used in a wide variety of commercial applications because of extended service life and cost efficiencies. Typical uses would include commercial signage, military lighting systems, emergency lighting, marine and aviation illumination systems.

REFERENCES:
1) http://www.labsphere.com/tech_info/docs/LEDTechGuide.pdf
2) http://chemistry.beloit.edu/BlueLight/pages/hp/abi004.pdf

KEYWORDS: LED, thermal resistance, low cost

A03-218 TITLE: <u>MEMS/Smart Sensor for Hydraulic Fluidic Analysis</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Heavy Tactical Vehicles

OBJECTIVE: Call for research on a methodology to obtain hydraulic fluidic analyses to maintain high-performance servohydraulic systems. Due to closely held clearances and tolerances in servovalves, high-performance servohydraulic systems require extremely clean oil. Oil contamination and deterioration, although normal consequences of hydraulic systems, is the major cause of severe fluid breakdown if not properly monitored. Contamination and deterioration are commonly caused by particles of metal, rubber, or dirt, along with entrapped air and water that is introduced into the system. A MEMS smart sensor to actively monitor the changing conditions of high-performance servohydraulic systems would prove to be a faster, better, cheaper method of monitoring hydraulic fluid integrity.

DESCRIPTION: Fluid sampling and analysis is the traditional method for determining hydraulic oil condition, and is often the indicator used to determine when both fluids and filters should be replaced. Properties such as viscosity, particle count, water contamination, and chemical composition are critical to fully analyze the quality of the hydraulic oil.

A multi-tasking MEMS smart sensor, that can be strategically located at various parts of the servohydraulic system can ultimately monitor the above properties in real time, eliminating the need for fluid sampling and analysis. Elimination of fluid sampling and analysis can prove to be a cost effective means of monitoring hydraulic oil condition. By actively monitoring the hydraulic oil's integrity, whether or not an additive package can still be utilized can be an alternative to replacing hydraulic oil. Additive packages will balance the chemical composition of the hydraulic oil to acceptable standards.

PHASE I: Develop overall system design that includes specification of MEMS-type smart sensor technology.

PHASE II: Develop and demonstrate a prototype system in a realistic environment for MEMS-type smart sensing of hydraulic fluidic analysis. Conduct testing to demonstrate robustness of hydraulic fluidic analysis sensor.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications where real-time, automatic hydraulic fluidic analyses are necessary.

REFERENCES:
1) Semiconductor Sensors by S. M. Sze (Editor); Publisher: Wiley-Interscience; (October 1994); ISBN: 0471546097.
2) The MEMS Handbook by M. Gad-El-Hak (Editor); Publisher: CRC Press; (September 27, 2001); ISBN: 0849300770.

KEYWORDS: Smart Sensors, Hydraulic Fluidic Analysis, High-Performance Servovalve, Hydraulic Oil, Fluid Sampling, MEMS, Chemical Composition

A03-219 TITLE: Intra Vehicle Adaptive Computing, Network Security, and Networking Using Ultra Wideband (UWB) Technology

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM BFVS

OBJECTIVE: The objective of this project will be to investigate the use of adaptive computing, security, & Ultra Wideband technologies for intra vehicle data, audio, and video networks in military vehicle and implement the same in a prototype vehicle to demonstrate the technologies.

DESCRIPTION: Tomorrow's Army will require large amounts of data to be securely transmitted and received within the vehicle over a data communications infrastructure that can adapt to a dynamic battlefield. Specifically, data fusion for FCS C4ISR and Platform networking will require advanced information technology that will allow large amounts of data to be transmitted and received within the vehicle while maintaining Quality of Service requirements for successful missions.

The Army's Objective Force will be network centric and include high speed data, video, audio, sensor, and radio type networks and therefore depend even more on timely and effective information exchange throughout the digitized battlefield. In addition, the amount of data exchanged will continue to grow at an astonishing rate as digital imagery, video, audio, and mapping data interchange becomes common place. Advanced data communications and networking technologies will be required to support these future information exchange requirements. Intra-vehicle network security requirements for unauthorized access also needs to be investigated and defined for platform, data, and knowledge safekeeping. The investigation will also include simulation of the system as needed. To demonstrate the design viability, a prototype system design will be undertaken to demonstrate the security features. In addition, specific tests should be performed with attempts to intrude into the network in various ways and verify its vulnerability in terms of security, if any.

PHASE I: Research the areas of advanced adaptive computing, network security and use of ultra-wide band technology (UWB) to increase overall system response effectiveness. Study how adaptive computing, network security and UWB technology can be effective applied to components found in a military ground vehicle environment. Develop technology performance matrix. Develop a plan to implement this technology into a military vehicle. Provide a final report that includes a preliminary design of a general-purpose adaptive computing interface device with a secure UWB network and recommendations for the follow-up effort.

PHASE II: Refine the design of the general-purpose adaptive computing and interface device to reflect latest technology advances. The device shall use UWB technology and consist of a secure UWB network that is shielded from human, faults, and virus threats. Develop, and demonstrate a prototype networking platform in a realistic environment. Conduct testing to prove feasibility over extended operating conditions. Update baseline performance matrix.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian applications where reliable networking and computing are necessary – for example, telecommunication, Robotic automobile production lines, or any commercial application that requires, flexible, inexpensive, secure, high speed, high data density, wireless information flow. For military use the technology would be incorporated into various components inside a military vehicle. The technology will allow the components to communicate as necessary from inside or outside the vehicle without use of a direct connection, thus eliminating the need for wires or fiber optics. Not only will there be weight savings because of the elimination of cabling, there will be increased placement flexibility between the components.

REFERENCES:
1) Fabio M. Costa, Gordon S. Blair, Geoff Coulson, Experiments with Reflective Middleware, Workshop on Reflective Object-Oriented Programming and Systems, ECOOP'98, October 1998.
2) Gordon S. Blair, Geoff Coulson, The Case for Reflective Middleware, Distributed Multimedia Research Group, Date unknown.
3) Seth Copen Goldstein, Electronic Nanotechnology and Reconfigurable Computing, IEEE, 2001.
4) John A. Zinky, David E. Bakken, Richard E. Schantz, Architectural Support for Quality of Service for CORBA Objects, Theory and Practice of Object Systems, April 1997.
5) Christober D. Gill, David L. Levine, and Douglas C. Schmidt, The design and performance of a real-time CORBA Scheduling Service, Department of Computer Science, Washington University, Aug 1998.
6) Rachid Helaihel and Kunle Olukotun, JMTP: An Architecture for Exploiting Concurrency in Embedded Java Applications with Real-time Considerations, Proceedings of the 1999 International Conference on Computer-Aided Design (ICCAD), pp. 551-557. November 1999.

KEYWORDS: Data Throughput, Security, Interoperability, Network, Intelligent agents, Reflective middleware, Reconfigurable computing.

A03-220 TITLE: Multiperspective Autostereoscopic Display

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Brigade Combat Team (BCT)

OBJECTIVE: To build an autostereoscopic device to allow the user to see 3D without glasses or headgear.

DESCRIPTION: Information Display is vital to the warfighter both in cockpit displays and also in robotic teleoperation. You can imagine that the information from a camera for teleoperation should exactly mimic the view you would see as if you were there. The best way to do this is with a "virtual window" like that seen in holograms. Autostereoscopic displays try to mimic holography in that you get two perspective views, one for each eye. The problem with current designs is that many are not truly multi-perspective, i.e., you can't look around objects in the foreground to see those in the background. The objective of this project is to design and build an autostereoscopic device that provides many stereo perspectives to the viewer. Three broad classes of technology [1] are used in multi-view autostereoscopic displays:
1) Spatial Multiplex: the resolution of a display device is split between the multiple views. [2]
2) Multi-projector: a single projection display is used for each view.

3) Time-Sequential: a single very fast display device is used for all views
Proposals from any of these classes are encouraged. Proposals that can find new ways to approach this problem are even better. [3]

PHASE I: During Phase I, the contractor will design the system from the ground up, including designs for color. Resolution and distortion of the image should be modeled for performance. Long-lead items, or high risk items should be outlined during Phase I for development during the Phase I extension.

PHASE II: During Phase II, actual construction of the prototype will begin. Prototypes should have multiple perspective views (8 or more would be considered adequate). Also, the bidder may have a design with continual perspective views. For this type of prototype, provide an arc of 15 degrees of continuous stereo.

PHASE III DUAL USE APPLICATIONS: The commercialization potential of 3D has greatly expanded over the past decade. To teleoperate robots, you need accurate visual cues.[4] For instance, when you are looking at a scene with objects in the foreground and background, sometimes the scene is cluttered and objects in the background are obscured by objects in the foreground.[5] When you are looking through a stationary camera, there is nothing you can do. However, with parallax, you can move your head to look around objects in the foreground to see objects in the background. This could be very useful in hazardous waste removal, teleoperation of mine clearing robots, and especially for robots that have to be operated in caves or sewers.

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1) N. A. Dodgson "Autostero displays: 3D without glasses" Electronic Information Displays Novermber 1997.
2) www.dti3d.com.
3) Thomas A. Nwodoh and Stephen A. Benton, "Chidi Holographic Video System" SPIE Proceedings on Practical Holography, vol. 3956, 2000.
4) M. Siegel "Just enough reality: comfortable 3-D viewing via microstereopsis" IEEE Transactions on Circuits and Systems for Video Technology April 2000.
5) L. Lipton "Stereo3D Handbook" downloadable from www.stereographics.com.

KEYWORDS: autosteroscopic, autostereo, stereo, virtual window, 3D, information displays

A03-221 TITLE: Replacement of CRT-Based Displays

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Develop an innovative replacement technology to replace current CRT-based displays. The replacement technology should provide a path to address the limitations of current mobile CRT devices, including single color limitations, high-voltage, high power consumption, and lack of reconfigurability. Display technology should have an advancement path that includes color display capability. Voltage through any tethers should be less than 50V.

DESCRIPTION: Using new technologies in Micro Electro-Chemical Systems (MEMS), replace current CRT-based displays with adaptable, low-voltage, color displays, to include those fitting upon the helmets of soldiers for weapons controls or for weapons sights.

PHASE I: Contractor should investigate new methods of visualizing images using MEMS (Micro Electro-Chemical Systems) and model prototype designs of a laser-based scanning display system using wavelength conversion as a CRT replacement technology for military targeting systems. The light source candidates should include, but not be limited to, violet or ultraviolet emitters that strike a wavelength converting material to produce visible light. The target display specification should include a 2 inch diagonal area with a brightness exceeding 100ftL. As a minimum, the analysis will determine power requirements, size, weight, operational issues, technology issues, and compatibility. 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 constructed in Phase II.

PHASE II: Contractor should design, build, and integrate a benchtop version of one or more of the display system prototypes of Phase I. The prototype will include a MEMS miniature scanner with a minimum resolution of VGA and a target resolution of SVGA. The contractor will test the prototype according to the plan developed in Phase I.

PHASE III DUAL USE APPLICATIONS: The contractor will build a mobile display pre-commercial display, along with packaging concepts appropriate for commercial products. The contractor will perform additional tasks relating to commercialization, including development of highly integrated video and control circuitry, in the form of an application specific integrated circuit, field programmable gate array, or similar. The integrated circuitry and display will be in a form adaptable for the diverse governmental display formats.

The size, cost, voltage & power consumption of such displays gives them broad applicability to commercial markets. Among these, the technology can be adapted easily for software reconfigurable dashboard applications for automotive, industrial, and aerospace applications. Because the technology can be extended to full color displays, the applications are even broader. Further, the technology enables small format projectors for mobile applications, such as cell phone conferencing. As power levels increase, the technology can enable medium to large format displays for desktop or larger applications.

REFERENCES:

1) D. G. Hopper and D. D. Desjardins, Aerospace Display Requirements: Aftermarket and New Vehicles, Proceedings of the 6th Annual Strategic and Technical Symposium "Vehicular Applications of Displays and Microsensors" (Society for Information Display (SID) Metropolitan Detroit Chapter, 1999) pp.59-62. (Noting that 503 of 866 display sizes in the military are unique.)

2) D. G. Hopper, "Invited Paper 21st Century Aerospace Defense Displays," in Society for Information Display (SID) Symposium Technical Digest, Session 29 ("Applications: Airborne Displays,"Paper 29.1, pp.414-417. (Noting the vanishing vendor syndrome for CRT vendors.


KEYWORDS: CRTs, Helment Mounted, Weapons Sights and Micro Electro-Chemical Systems (MEMES).

A03-222 TITLE: Integrated High-Performance Remote Visualization Capability

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Brigade Combat Team (BCT)

OBJECTIVE: Development of high-end remote transmission techniques to handle video, keyboard/mouse, serial, and audio signals for use in a centralized graphics-based supercomputer to run a multi-projector fully-immersive 3D stereo display device in real time at a remote location.

DESCRIPTION: The concept of “remote visualization” is highly sought after for several reasons, such as to leverage computing resources at remote locations and promote project collaboration, ultimately leading to cost savings and consolidated resources. Although “remote visualization” has several meanings, the approach pursued here is to use a centralized, non-Windows based, high end graphics-based supercomputer to run a multi-projector fully-immersive display device in real time at a remote location. The distance between these locations can be hundreds or even thousands of miles apart. This initiative would seek to develop and implement a real-time signal transmission capability to include: 3D stereo video refresh rates at 96 Hz using a stereo sync signal, multiple serial communication streams (to allow wand, haptic, and tracking systems to communicate with the remote computer), and to address how multi-channel surround sound audio signals could be transmitted. Because this transition capability will be an extension to remote sites, a means for controlling these signals must be investigated that allows its incorporation into any current local computing environment.

A scalable technique that can provide a large number of possible input and output ports (such as “128x128” or “256x256”) for signal management should be considered. Such a technique must support keyboard/mouse (PS/2 or USB), video (13W3 or HD15), serial (DB9), and audio (RCA) connections. Further, it should have secure communications and be highly programmable. Settings, macros, defaults, etc, should be easily configurable and be based on a standard communications protocol (i.e., RS232) that will allow it to be controlled through independent, outside front-end interfaces including custom-written scripts issued by remote computers, web interfaces, or programmable wireless remote control devices.

PHASE I: The contractor shall research, design, and propose the necessary hardware architectures and techniques to transmit, receive, and manage all the signals described above. A process for acquiring and implementing a high-bandwidth link using commercially-available telecom service as well as the DoD's "Defense Research Engineering Network" (DREN)-available access points should be investigated. Design of a robust graphical user interface to control the management of the signals is necessary.

PHASE II: The contractor shall develop and implement the techniques, hardware, and any related software designed in Phase I. Tests and performance benchmarks should be conducted to demonstrate robustness using various video formats through a variety of visualization applications. Implementation and configuration of a graphical user interface is to occur.

PHASE III DUAL USE APPLICATIONS: The technology to be developed through this research is currently sought after by organizations in government, academia, and industry that use such high-end computing resources and graphical display devices. For potential commercial applications, further research and development of the techniques and hardware explored here are necessary to offer a reduced bandwidth version using compression techniques. Its use will immediately benefit the Future Combat System (FCS) mission.

The Army stands to benefit from such an initiative in many ways including the advancement of our collaborative efforts using virtual immersive environments, having TACOM-TARDEC continuing as the proponent DoD activity to use and advance such technology, and the potential for expanding the Army's customer and project base by offering such high-end graphics technologies to locations not as familiar with them throughout industry, academia, and TACOM-TARDEC business partners.

REFERENCES:
1) Society of Automotive Engineers paper #2003-01-0217, titled "A Super Visualization Environment - Technology Enabling Army Transformation".
2) Lightwave/Lantronics : http://www.lantronix.com
3) Teraburst : http://www.teraburst.com/news/pr_100802_sgi.html
4) Blackbox : <http://www.blackbox.com>

KEYWORDS: remote visualization, Advanced Collaborative Environments, Teraburst, Lightwave, signal switching, video transmission, virtual reality

A03-223 TITLE: Integration of Vehicle Models and Analytical Simulations

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM-MVT

OBJECTIVE: Development of UNIX- or Linux-based routines that will natively read physics-based, multi-body, dynamic analysis results for use on high-end, multi-projector, virtual immersive environment visualization display devices. Applications and practices currently do not exist that support such a requirement, nor do they take advantage of parallel processing techniques to increase interactive performance.

DESCRIPTION: A valuable capability for vehicle dynamic simulations is to visualize the results using Computer Aided Design (CAD) solid models and time/position dynamic data generated through computationally-intense vehicle dynamic analysis applications (such as LMS Virtual Lab, formerly CADSI DADS, or McNeil Schwendler's Adams software). Various TACOM-TARDEC organizations are making progress in using analytical output to create accurate vehicle animations. However, at best, this is a multiple step, time consuming process that requires conversion of the analytical results and/or the geometry CAD models and usually results in additional programming and a loss of fidelity and accuracy. Many of the advancements are "home grown" and are not robustly supported or readily extendable to other aspects of the vehicle design process. For example, analytical simulations are performed and visualized using low-resolution/low-fidelity (simple geometry) models, while the high-resolution (textured and animated complex geometry) images are usually created from scratch, and do not include analytical results. Eliminating this "disconnect" between these two levels of effort will greatly enhance a vehicle design process (both military and commercially). The research and development of software routines sought through this SBIR should specifically and uniquely incorporate the analytical simulation results with the high-resolution models that can be used for animations and virtual immersive environment purposes.

PHASE I: The contractor shall experiment with, propose, and finalize appropriate data file formats, features, and protocols that will dynamically and interactively incorporate the immediate recognition of common dynamics analysis packages (such as Virtual Lab or ADAMS) with a highly-detailed solid geometry CAD model (such as PTC ProE or Unigraphics). The design methodology should emphasize the ability to take advantage of a multiple processor system through parallel processing and shared memory techniques. Mathematical representations, computational procedures, and image generation schemes to allow user interaction with performance of 15 or more frames per second should be developed.

PHASE II: Implement the functionality determined in Phase I. Demonstrate the application by using current TACOM-TARDEC data. Extend the research and development to include performance of 30 or more frames per second. Further refinement of the application, interface, and image generation schemes will be necessary to increase accuracy and robustness of results.

PHASE III DUAL USE APPLICATIONS: Such an application would ultimately become a commercial-off-the-shelf, fully-supported software application. TACOM-TARDEC, its automotive and academic partners, and industry can immediately take advantage of this much needed dynamic/vehicle design capability. Such research will address a capability that would significantly enhance the development of any vehicle system (military or commercial, tracked or wheeled) through physics-based analysis and immersive-environment visualization and interaction with the data.

REFERENCES:
1) Opticore : http://www.opticore.com/
2) Parametric Technologies : http://www.ptc.com/
3) Adams : <http://www.adams.com/>

KEYWORDS: Modeling & Simulation, Advanced Collaborative Environments, dynamic analysis, scientific visualization, CAD

A03-224 TITLE: Development of High-Resolution Virtual Terrain for Use in a Motion-Based Simulator with an Image Generator

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, FCS

OBJECTIVE: To research, develop and demonstrate an innovative methodology to improve the rendering of terrains using image generators for use with training and engineering simulators. This terrain rendering methodology will increase the level of realism dramatically in the simulators, thereby providing the users with a more realistic development and training environment. This SBIR will apply directly to the recently approved STO IV.GC.2003.01 - High Fidelity Ground Platform and Terrain Mechanics Modeling.

DESCRIPTION: The effectiveness of standard training/engineering simulators is reaching a plateau. Current simulators provide a crew-station mockup for the occupants, an audio system for creating proper audio cues, an image generation system which renders visual information (usually the war-gaming or testing environment) and for high-end simulators, a motion-base to provide dynamic motion to the crew.

With the increasing applicability of simulation to all aspects of the product development cycle, from inception to user testing and finally testing, a more realistic and affordable simulation solution is needed. Perhaps the most important cue the crew needs is a realistic visual representation of the environment they are in. Image generators are limited in the resolution they can render in terms of polygonal throughput. Up until now, to get a more realistic image, you had to render more polygons in the scene, which is impossible to do in a real-time simulation.

One alternative technique is to modify the texture maps that are applied to the polygons using a technique called bump-mapped texturing. This technique takes advantage of image generators using Phong shading and lighting models. By perturbing each pixels surface normal vector, realistic shading is created without the additional compute burden of adding more polygons.

A solution to this problem is to develop a separate, high-resolution terrain database for use as an input to the dynamic model but yet correlated to the image generator's visual terrain database. This high-resolution terrain database would provide higher frequency terrain inputs to the dynamic model. This high-resolution terrain database can be rendered visually using the above mentioned technique, thus, the crew would feel and see a truly realistic scenario and the level of immersion in the simulation becomes almost realistic.

PHASE I: The contractor shall research, study and develop an innovative approach for developing a high-resolution correlated terrain skin and how to render it on an image generator. The use of Phong shading techniques along with bump-mapped texturing to increase the visual resolution shall be investigated. The contractor is free to decide as to the methodology for adding high-frequency disturbances to the existing lower-resolution terrain skins. The proposed methodology shall allow the resultant high-resolution terrain skin to be both visible on an image generator and available to the real-time dynamic model during execution during a simulation. The contractor shall deliver a detailed report as to the conclusions and methodologies they would suggest to help solve this problem.

PHASE II: The contractor shall extend the research and development of the methodologies from Phase I to provide a user-friendly software package which will read in an existing lower-resolution terrain skin, add higher-frequency disturbances and visually render this new terrain. A demonstration of this technology will include a complete simulation using the motion-bases and image-generators located at TARDEC along with the real-time modeling network and image generators that exist in the Ground Vehicle Simulation Laboratory. This phase will demonstrate the feasibility of this technique.

PHASE III DUAL USE APPLICATIONS: This new methodology would be extremely useful to all facets of computer image generation, from military uses to commercial needs to the gaming industry. Since many low-end image generators and pc-based image generation cards are now using the Phong shading technique, it is readily applicable.

REFERENCES:

1) A. A. Reid and S. A. Budzik, “Development of a Virtual Proving Ground Using High Resolution Terrain”, I/ITSEC 2000 conference, Nov 2000.
2) A. A. Reid, “Parametric Terrain Surface Development”, IMAGE 2000 conference, July 2000.
3) A. A. Reid, “Development of the Optimum Training Simulator”, Army Science & Technology Magazine, November 2000.
4) P. Bounker, M. Brudnak, P. Nunez, M. Palazzolo and A. Reid, “High Fidelity Unmanned Ground Vehicle Modeling”, 2002 Spring Simulation Interoperability Workshop, Mar 2002.
5) Mark Brudnak, Patrick Nuñez and Alexander Reid, “Real-time, Distributed, Unmanned Ground Vehicle Dynamics and Mobility Simulation”, SAE 2002 World Congress, Mar 2002.
6) Alexander A. Reid, “Development Of A High-Resolution Virtual Terrain To Support The Development And Testing Of Intelligent Systems”, 2002 NDIA 2nd Annual Intelligent Vehicle Systems Symposium, Jun 2002.
7) Patrick Nunez, Alexander Reid, Randy Jones, “A Virtual Evaluation Suite for Examining the Stability, Handling, Ride, Mobility, and Durability of Conceptual Military Ground Vehicles”, 2002 SAE International Truck & Bus Meeting & Exhibition, Nov 2002.


KEYWORDS: simulation, image generator, bump-mapping, texture, terrain, motion-base, resolution

A03-225 TITLE: Computational Modeling of Nanostructures

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM SURVIVABILITY

OBJECTIVES: Due to extremely small size of nanostructured materials there are considerable difficulties and material and time costs involved with the experimental characterization of their properties and behavior. Computer modeling at nanoscale has inevitably become a necessary supplemental and complementary tool to experimental nanoscience investigations for predicting and tailoring the engineering properties of nanostructured materials. It is the objective of this research to develop accurate computational tools for modeling and simulation of nanoscale phenomena that will provide the detailed information not easily available from experiments and would lead to accurate predictions required for processing and design of nanostructures. In particular, the research is aimed at computational modeling of functionally graded materials (FGMs) under thermomechanical loads.

DESCRIPTION: Future military vehicles should have higher strength and less weight compared to their present day counter parts while equipped with multifunctional sensing and actuation elements for proper response to harsh battleground conditions. Nanotechnology and nanostructures will play a key role in achieving these challenging requirements. Traditional models and theories for predicting material properties and design analyses involve assumptions based on “critical scale length” that are generally larger than 100 nanometers. When at least one dimension of the material structure is under this critical length, distinct behavior often emerges that cannot be explained by traditional mechanics models and theories.

A great deal of work has been performed in atomistic modeling that includes Molecular Dynamics, Force Fields, Quantum Mechanics, and Statistical Mechanics. However, due to their immense computational requirements, practical application of these techniques are limited. On the other hand, classical continuum mechanics models neglect some nanoscale characteristics of these materials and are unable to account for all forces acting at nanoscales. Therefore a need for an efficient modeling technique that can simulate the static and dynamic mechanical response of nanostructures at the atomistic scale is emerging.

Some recent works exploring the similarities between carbon nanotubes and large scale structures have shown promising results where methods of computational structural mechanics are used at atomistic scale though correspondence between force field in computational chemistry and structural frame element parameters. Extension of this approach for modeling and simulation of nanoscale structures to predict the needed material characteristics of these materials is highly promising, and it will fill the existing gap in utilizing the nanotechnology for future military and commercial applications.

PHASE I: During Phase I of this research the theoretical framework of the nanoscale modeling should be investigated and formulations showing correspondence between force field chemistry and frame element parameters should be presented and feasibility of the proposed method should be shown based on existing theoretical and experimental data. In particular, mathematical models and computational procedures to analyze nanocomposites and functionally graded materials should be developed.

PHASE II: Numerical implementation of the theory, software developments and validation and verification should be pursued in Phase II.

PHASE III: Commercialization of the developed mathematical framework for the study of nanomaterials (e.g., nanocomposites and nano FGMs) should be the goal of Phase III.

MILITARY AND COMMERCIAL BENEFITS: The outcome of this research in mathematical and computational modeling of nanostructures leads to the next generation of high performance materials, that are much harder, stronger, lighter, more reliable, and safer so that they last many times longer than our current technology allows. These materials will be an integral part of future military vehicles and will make our infrastructures such as bridges, roads and lifeline utilities more reliable and safer. The means of transportation by ground, water and air spacecraft need lightweight for greater maneuverability, and yet functionally designed materials: strength for function and safety, low weight for fuel economy, maneuverability and agility, and low failure rates (wear, corrosion, fracture, and fatigue) for life-cycle cost and waste reduction. Present military/space platforms have material limitations on their duration and performance that are clearly deleterious to mission success. With the incorporation of sensing/actuation functions directly into materials, these smart materials will have condition-based maintenance (reducing the enormous cost of multi billion dollar per year associated with materials replacement) and will provide new materials capabilities. One military application would be stealthy materials that can recognize probing radar or sonar beams and initiate an action that gives no return signal. Automobile and aircraft materials could also be made to sense incipient failure and warn the user well in advance. In medical applications, nanomaterials will make self-regulating pharmaceutical dispensers compatible with biosystems so that they will not be rejected by the human body and will last many times longer in the corrosive and mechanically harsh environment of the human body.

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KEYWORDS: Nanoscale; Nanostructures; Nanotechnology;Computational Modeling and Simulation; Computational Mechanics; Computational Chemistry, Nanosale Simulation

A03-226 TITLE: Integrating Stochastic Engineering Models in a Distributed Environment

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, FCS

OBJECTIVE: Development of distributed/computational design optimization techniques to improve vehicle system/subsystem performance-based analytical models through the incorporation and management of model parameter uncertainties characterized by Probability Density Functions (PDFs).

DESCRIPTION: In order to quantify uncertainty in modeling, and assess the reliability of designs, their robustness, and risk associated with them, stochastic methods must be applied to dynamic and finite element modeling in a distributed, high-performance computing environment. Methods such as robust design optimization and fast Monte Carlo methods should be considered. Other methods such as particle filters (sequential Monte Carlo methods) based upon point mass representations of probability densities based on given parameter set shall be investigated.

Lack of information, model uncertainty, material uncertainties, and stochastic inputs should all be considered. Resulting point clouds of results should be spatially analyzed as to how to change the clouds for maximum robustness and optimality which will require a multi-dimensional visualization capability. Because of the parallel nature of the problem, the optimization methodology can be mapped to multiple processors to increase computational efficiency

PHASE I: The contractor shall research, design, and develop a robust vehicle design optimization methodology to introduce model parameter "uncertainty" in a deterministic modeling environment. Commercial rigid/flexible body and FEA codes may be used but the parameter and input data sets must be represented by Probability Density Functions (PDFs). The design methodology shall have the ability to be mapped on to multiple processors for speed optimization using such standard parallel techniques as shared memory, message passing interface (MPI), etc. while preserving mutual exclusion. Additional emphasis must be made on visualization of the resultant point clouds for analysis. Target platform will be a small ground vehicle system.

PHASE II: The contractor shall extend the research and development of the robust optimization methodology from Phase I into a working "user friendly" software package. Tests should be conducted to demonstrate the accuracy, robustness, and performance of the methodology in a variety of conditions.

PHASE III DUAL USE APPLICATIONS: The design methodology developed above in the description can be used in a broad range of military and civilian applications. For potential commercial applications, research shall be conducted for implementation into mobile robot/small vehicle design and performance evaluation. Research also shall be conducted for implementation into the Future Combat Systems (FCS) mission.

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KEYWORDS: robust, optimization, vehicle design, stochastic environments

A03-227 TITLE: Exploratory Development for A Controllable Combustion Process for Improved Power-Density and Fuel Economy within Multi-Fueled, Low Heat Rejection Compression Ignition Engines

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, Future Combat System (FCS)

OBJECTIVE: Research, design, and develop an engine combustion process capable of combustion near stoichiometric air/fuel ratio at higher engine speeds under high boost conditions. The combustion system should exhibit good cold startability, and fuel economy. The engine projected specifications are as follows:
Ratio of power/engine weight= 1.00 hp/lb
Ratio of power/ engine volume = 30 hp/cu ft
Ratio of power/ propulsion system volume = 5 hp/cu ft
Brake specific fuel consumption, (BSFC) = 0.32 to 0.40 lb/hp-hr
Brake mean effective pressure, (BMEP) = 18 to 25 bar
Power to total engine displacement = 1.40hp/cu in
Specific heat rejection to coolant = 12 to 17 btu/hp-min
Specific heat rejection to ambient = 2 to 3 btu/hp-min
Super-turbocharger compressor output pressure= 4 to 5 bar
Air/fuel ratio = 15/1 to 25/1

DESCRIPTION: Conventional multi-fueled CI combustion systems have poor air utilization due to inadequate fuel/air mixing in the time available for combustion to take place. Low compression ratio designs can improve engine performance under high boost levels, however, these designs are limited by their ability to operate under light load conditions, and during cold start. Low Heat Rejection technology can improve part load operation by maintaining higher in cylinder surface temperatures, but at the expense of reduced volumetric efficiency, particularly under high load conditions. The research work on this project is to seek an advanced combustion technology that can improve on each of these above mentioned shortcomings, and achieve optimum solutions. The proposed work is to research, design, modify, and consult experts in the fields of combustion, tribology, heat rejection, coatings, ceramic, hydrodynamic and boundary lubrication, high temperature lubricants, cooling, induction and exhaust manifolds, fuel injection, super-turbocharging, electronic controls, and high temperature materials, prepare the optimum advanced technology in these fields, and apply on the new controlled stoichiometric combustion process, and the early injection/combustion timing design for Homogeneous Charge Compression Ignition technology application. Also, the engine design is to incorporate a low compression ratio with high boost, high speed and good cold starting and multifuel capabilities.

PHASE I: The feasibility of the proposed technology must be assessed using mathematical computer programs, and modeling/ simulations technique. The prototype layout design and analysis of this new technology will start in phase I. The simulations and design should show the potential of this new technology to meet/ exceed objective targets.

PHASE II: Finalize the engine prototype layout design, fabricate the critical engine parts, build a prototype demonstrator engine using an appropriate engine block, test it for performance in a certified laboratory-dynamometer test rig. Continue performance testing of the engine for part and full load. Correct potential failures, and test for engine life cycle/condensed endurance test hours. Analyze, assess and correct any potential failure(s) as a result of the performance and endurance testing processes. Prepare the engine for further testing at government propulsion laboratory.

PHASE III DUAL USE APPLICATIONS: This new engine technology of (near stoichiometric combustion, homogeneous charge, low compression ratio, high boost, high speed, good cold starting, and multifuel combustion capability), will be potentially used on both military and commercial propulsion system applications.

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KEYWORDS: Stoichiometric air/fuel ratio, controlled combustion process, injection/combustion timing, homogeneous charge compression ignition technology application, low compression ratio, high boost, high speed, cold starting, multifuel, tribology, coatings, high temperature materials, hydrodynamic, boundary

A03-228 TITLE: Passive Thermal Management for Next Generation Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat System

OBJECTIVE: Develop, demonstrate, and integrate advanced, lightweight, passive Thermal Management hardware for cooling mission critical technologies in next generation vehicles. The next generation of vehicles, tactical and commercial, may incorporate fuel cells, electric or electric – internal combustion hybrid propulsion systems, and "drive by wire" auxiliary systems, each of which poses unique cooling problems. Replacing mechanical and electromechanical systems with electronically controlled devices eliminates many routes of thermal communication between heat generation and dissipative sites. This revolutionary change in vehicle propulsion and control requires a similar change in thermal management. Advanced, lightweight, passive thermal management systems must be developed to keep pace with automotive technology.

The Army's next generation of weapon systems (FCS) and tactical vehicles (21st Century Truck) will be designed with stringent requirements on survivability, efficiency, and performance. Electronics and electronic control is necessary to achieve these requirements. However, increased reliance on electronics complicates thermal management by distributing more energy throughout the vehicle structure. An innovative hardware solution is required to collect thermal energy from distributed sources.

Many DoD initiatives propose autonomous robotics for weapon systems, logistical support, and RSTA sensor suites. Robotic vehicle platforms possess limited onboard battery life and power is at a premium. Therefore, the use of power to support ancillary cooling systems is unacceptable. A passive thermal management system is required for this application and is applicable to all related DoD programs.

DESCRIPTION: An innovative hardware solution is required to produce a thermal management system capable of collecting thermal energy from distributed sources and dissipating it at a discrete location. This type of system is referred to as a 'Thermal Bus'. The ideal thermal bus technology operates passively, and provides high power dissipation at a low temperature difference, low cost, and small weight/volume penalty. Passive operation eliminates the drain on limited system power resources. High power dissipation at a low temperature difference minimizes thermal signatures. It should also allow significant design and integration flexibility.

Harsh operational environments upon deployment further complicate thermal management of next generation vehicles. The vehicle environment consists of ambient temperature extremes ranging from –54 to 85o C (1; 2). Maximum temperatures typical of an automobile electronic environment vary from 140o C on the engine or transmission to 70o C in the passenger compartment (4). Mechanical shock, vibration, electrical load duty cycles, dust, and steady or transient acceleration induced forces exist. All environmental parameters must be considered during concept development.

PHASE I: Goals for Phase I should include a feasibility demonstration (e.g., concept analysis and subscale experiment) of the proposed thermal management hardware concept, address integration issues, and provide sufficient analysis to demonstrate system level payoffs.

PHASE II: Goals for Phase II should include sufficient demonstration of the proposed thermal management concept to show integration viability into a vehicle platform.

PHASE III 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 represents numerous technical challenges requiring innovative solutions which in turn can be directly applied in the military and private sectors.

REFERENCES:
1) "Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)," Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001, J1455, 1994.
2) "Recommended Environmental Practices for Electronic Equipment Design-SAE J1211," Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001, J1211, 1999.
3) Birur, Gajanana C., Johnson, Kenneth R., Novak, Keith S., and Sur, Tricia W., "Thermal Control of Mars Lander and Rover Batteries and Electronics Using Loop Heat Pipes and Phase Change Material Thermal Storage Technologies," SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, 2000.
4) De Vos, Glen W. and Helton, David E., "Migration of Powertrain Electronics to On-Engine and On-Transmission," SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, 1999-01-0159, 1999.
5) Suitability of Loop Heat Pipes for Thermal Management of Ground Vehicles, P. Rogers, U.S. Army TARDEC, J. Ku, NASA-Goddard Space Flight Center, C. Hoff, Lawrence Technological University, SAE/ImechE Vehicle Thermal Management Conference, London, England, May 1999.

KEYWORDS: Prototype Hardware,Thermal, Passive, Power dissipation, Electronics, FCS, Next generation vehicles, Robotics, signatures

A03-229 TITLE: Virtual Prototyping Vehicle Electrical System Management Design Tool

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Brigade Combat Team

OBJECTIVE: Investigate and study the issues related to the development of a management design tool for virtual prototyping of vehicle electrical propulsion systems for hybrid-electric vehicles. Determine the impact on the development process of these vehicle systems. Determine a reasonably-phased approach to implementation, and demonstrate the design tool modeling and simulating a vehicle's electrical system.

DESCRIPTION: The Army's next generation of weapon systems and tactical vehicles will be designed with stringent requirements on efficiency, performance, and survivability. To fulfill these requirements under constraints of development time and production cost, the operation of integrated systems must be optimized during the design process. Efficient electrical power utilization for vehicle systems and electric propulsion systems in hybrid-electric vehicles, versatile and efficient electrical power management, and cost-effective signature control and component integration with minimal power requirements must all be goals of the integrated design effort. This necessitates the development of a design tool that can efficiently optimize the design of these disciplines simultaneously. To meet these ambitious goals, the design tool must aim for integrated system-level design, yet be fully capable of accurately analyzing the details of the vehicle electrical system. No such tool exists yet.

An innovative solution is required to produce a fast vehicle electrical system solver that has the capabilities to analyze current, proposed, and potential vehicle-electrical and propulsion-electrical systems (42/28/14V and higher - (300-600V)for electric propulsion) and to determine the most effective and efficient system design to result in minimal power consumption, per system component and for the system as a whole, and maximal performance capabilities. This solver must be tied to accurate models of electrical power generation, distribution, and conservation. All component models must predict the power consumption, power densities, and efficiencies, as well as the heat generation by the component.

The CFD solver must be capable of analyzing complex electrical circuits and of modeling the electrical system for the vehicle under operating, idle, and stored conditions. The design tool must fully consider the effects of the environment, weather, and terrain on the system performance.

PHASE I: Contractor shall study and research the issues related to virtual design and prototyping (Modeling & Simulation) of current and legacy vehicle electrical systems as they apply to the development of the propulsion system in electric and hybrid-electric vehicles. Determine impact on development process of these vehicle systems. Determine a reasonably-phased approach to implementation, and demonstrate the design tool modeling and simulating a vehicle's electrical system.

PHASE II: Contractor shall implement approaches to designing the modeling-and-simulation tool discussed in Phase I on a candidate platform, clearly illustrating the dual-use nature of the design tool. Conduct a demonstration of this design tool, exemplifying its ease-of-use in the dynamic design process of vehicle electrical systems. Coordinate this effort with partners formed in Phase I.

PHASE III DUAL USE APPLICATIONS: Industry clearly needs a design tool to accurately Model & Simulate vehicle electrical systems in their development process, and a demonstration of the dual-use applicability of this tool will position a company to commercialize the results with the commercial sector.
The integration of rapid CFD with electrical/electronic design tools will be valuable to many vehicle design applications, both commercial and military.

REFERENCES:
Website: http://www.tacom.army.mil/tardec/vetronics/architecture.htm This website provides information regarding the subject matter's design tool.

KEYWORDS: dual-use, power management, component integration, systems engineering, modeling and simulation.

A03-230 TITLE: Transmission and Driveline Development and Their Components

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: Family of Medium Tactical Vehicles, LMTV & MTV

OBJECTIVE: The objective of this effort is to develop new technology transmission and driveline systems for military tactical wheeled and tracked vehicles. A second objective would be to develop new components within a transmission and driveline system which improve efficiency, reliability/durability and performance. A goal of these objectives will be savings through lower operation and service costs. In addition, development of new technology materials will be sought which can meet existing performance requirements while reducing weight by a minimum of 25%. Driveline systems include every component from the transmission to the vehicle tires or final drives. Components include, but are not limited to, the transfer case, propeller shafts, differentials, axles, geared hubs and final drives. Current development efforts are more focused on electric drive technology, however, future powertrain systems could include transmissions and conventional driveline systems. The conventional military driveline system is tailored to specific military vehicle requirements and continual advanced designs are needed to maintain the latest state-of-the-art technology.

DESCRIPTION: New technology transmission and driveline systems and their components will be researched and evaluated to determine where substantial improvements in efficiency, performance and reliability/durability can be achieved. Efficiency improvements will be investigated in transmission/driveline new designs or new design transmission/driveline components. Examples for improving efficiency include: (1) draining of hydrokinetic transmission torque converter during gear engaged idle condition to reduce transmission input side spin losses and (2) transmission software design logic to match fluid fan horsepower requirements with transmission fluid safe temperature operating range. Efficiency improvements, for example, translate into smaller size fuel tanks for the same vehicle mileage range coverage. This could lead to increased space available for other vehicle needs such as additional ammunition or more cargo capacity.

New materials will be investigated, such as polymers, which could substantially reduce component weight of transmission/driveline systems. Major component weight reduction improves vehicle performance and saves fuel. New materials will be required to meet current performance requirements of transmission and/or driveline systems.

Development efforts for improving durability/reliability will also be investigated for new design transmission/driveline or existing transmission/driveline systems of major vehicles which exhibit short life. This would lead to reduced spare parts purchases and cost savings during a military vehicle’s usage. Some examples of transmission development efforts relating to durability/reliability include: (1) reducing transmission shift shock characteristics, (2) new transmission clutch materials, (3) new clutch pack activation devices (ex. cone, poly vee), and (4) new design approaches to improve cold oil flow requirements. Other transmission component development areas could include: (1) new gear set design (ex. coplaner), (2) new filtration design (ex. pressure line filter, partial flow type), (3) valve regulators, and (4) oil pump(s). Items (3) and (4) require increased life due to damage caused by contaminants which penetrate the transmission’s filter system. Note: a new design of an existing transmission filter is not applicable under this SBIR topic.

The development of new transmission/driveline systems or new design transmission/driveline components will provide a leverage in maintaining existing or future conventional transmission/driveline systems in the event electric drive or hybrid electric drive technology requires substantially more development time. This enabling technology will provide a needed development goal to advance the state-of-the-art new design transmission/driveline systems and their components.

PHASE I: In Phase I, the contractor will become knowledgeable of transmission and driveline systems and their components on military vehicles. Transmission and driveline systems and their components will be investigated which have reduced service life and where new design technology improvements can be implemented. A new design technology for a transmission and driveline system or a new developed transmission and/or driveline components must consider military environments, current maintenance manual recommendations and practices and performance specifications military vehicles operate under. A proposed new technology transmission or driveline system must be able to fit within tight volume constraints of current production transmission or driveline system. The contractor will establish preliminary design, performance and sizing of new transmission or driveline system or new components of transmission and driveline system to verify if the new design concept is doable. Preliminary performance analysis, theoretical calculations and computational fluid dynamics or equivalent will be conducted to verify if the new design concept will work. Design goals will be to determine if new concept transmission or driveline system or new system components provide commonality and could effectively replace an existing system or component. A preliminary economic analysis will be performed to substantiate potential cost savings. At the end of Phase I the proof-of-principle must be demonstrated and enough evidence presented to verify the new concept appears to accomplish the following goals: (1) efficiency and/or performance improvements and (2) improved reliability/durability resulting in operation and support cost (OSCR) savings.

PHASE II: In Phase II the contractor's new designed transmission or driveline system or new developed transmission and/or driveline component will be extensively evaluated, re-engineered and design up-dated to assure the design concept provides feasibility. For example, if there is more than one design approach an assessment will be made based on trade-off studies to provide the best design concept. Computational fluid dynamics or equivalent will be continued to assure the best design concept is selected. A prototype transmission or driveline system or a new design transmission or driveline component will be fabricated and preliminary lab evaluation tests conducted to verify the design. The evaluation tests will confirm the projected improvements in efficiency/performance and/or reliability/durability. The contractor will continue to harden the design by making design changes to provide improvements in at least one of following areas: efficiency, performance, reliability and durability. At this time, the economic analysis will be up-dated and a determination made to assure that the new design provides an operation and support cost reduction (OSCR) to the affected military vehicle(s). The new prototype design transmission and/or driveline system or new component design for a transmission or driveline system will undergo more rigorous lab simulation tests which depict future field test environments. Following these tests, a technical assessment will be made by the contractor to determine final prototype design configuration (if required). At the conclusion of Phase II the contractor will deliver at least one (1) prototype.

PHASE III DUAL USE APPLICATION: Many military transmission and driveline system and their components are used in commercial applications. In addition, the Army buys many commercial construction, material handling and road building equipment which has dual use application. Cost savings are the bases for most new technological products. Success of the program described above will provide a direct link to a joint commercial and military endeavor.

REFERENCES:
1) TARDEC Technical Report No. 13802, TITLED: Test and Evaluation of the LMTV Driveline, Dated June 1999, Contractor U. S. Army Tank Automotive Research, Development & Engineering Center (TARDEC).
2) 2002 SAE Handbook, Volume 2 Parts & Components and On-Highway Vehicles, Standards Development Program, Section 29 Transmissions, Pages 29.01 to 29.248 , Published by Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.
3) Eleftherakis, John G., TITLED: Optimizing Automatic Transmission Filtration, SAE Paper 99PC-418, Dated 1998, Society of Automotive Engineers Inc., Warrendale PA.

KEYWORDS: Transmissions, Driveline, Transmission Components, Powertrain Components, Propulsion System Components, Improved Efficiency, Improved Perforance.

A03-231 TITLE: Develop New Innovative Filtration Designs and Components for Improved Service Life, Performance and Durability

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Light Tactical Vehicles

OBJECTIVE: The objective of this effort is to study, design, develop, improve and evaluate new filtration system components and components of existing filtration systems, which will lead to reduced maintenance and spare parts purchases, increased durability and improved readiness. This will provide an overall monetary cost savings during a military vehicle's yearly operational cycle. Individual efforts will focus on improvements in the following areas: (1) air filtration system improvements will look at new innovative air cleaner design concepts and/or new filter media materials which provide either a higher number of air filter cleanings and/or increased air cleaner dust capacity/service life by a factor of 2, (2) develop new technology engine and transmission oil filters including on-board sensors to detect filter clogging and fluid contamination. A goal will be to develop new technology oil filters which approach the life of the engine/transmission while improving performance and environmental friendliness, and (3) develop new technology engine fuel filters and/or fuel system components which provide longer service life, increased performance, higher efficiency, less maintenance and environmental friendliness.

DESCRIPTION: Engine induction air will look at new technique air filtration system improvements for high density vehicles such as the High Mobility Multi-Purpose Wheeled Vehicle (HMMWV) which currently uses cellulose base air filter media. With this media, the air filter is recommended to be cleaned only three (3) times before discard. In addition, the HMMWV air cleaner has a short service life of 16 hours based on lab testing requirements. This dictates that a new air cleaner design and/or new media material be developed to provide either a higher number of cleanings or much longer service life (2 times). New media material will consider the vibration effects an operating vehicle may transmit to the air cleaner housing to substantiate effects on air cleaner efficiency and longer service life/dust capacity.

Engine/transmission oil filter technology will be developed to provide increased oil filter service life and efficiency while maintaining fluid quality. Military vehicles with a current recommended replacement interval for engine/transmission oil filters will be investigated to show where improvements are possible. A new design filter will be required to fit within space allocation of existing filter. Oil filters with on-board sensors will be developed to detect when an oil filter is in the bypass mode (filter clogging) and if fluid is becoming contaminated. Transmission oil filters will be developed to replace existing transmission oil filter and this SBIR topic will not consider development of combination pressure line filter (ex. partial flow type) in addition to main sump filter. Transmission oil filters will investigate new innovative designs, which provide higher efficiency which maintaining the cold oil flow requirements of transmissions.

Fuel filter technology will be developed to demonstrate improved filter life and efficiency. Related fuel technology to be looked at includes: (1) temporary by-pass fuel system, (2) diagnostic sensors to detect percent of filter life left, and (3) improved water separator performance and service life. In addition, smart fuel pump(s) installed in fuel tank(s) which require considerable maintenance time for diagnosis will be developed to provide a quick check for satisfactory operation. The smart fuel pump with an on-board sensor would be a cost driver for minimizing maintenance costs. Fuel filters and fuel system components technology will also demonstrate cost savings forecast for any new design.

PHASE I: In Phase I the Contractor will become knowledgeable of filtration systems on current military vehicle fleets and military vehicle operational annual mileage and usage conditions. The new proposed filtration system concept must consider military environments, current maintenance manual recommended interval cleaning or replacement and performance specifications military vehicles operate under. The proposed filtration or filtration component concept must consider engine manufacturer requirements for induction air, fuel and oil as applicable to a particular engine design and be able to interface and fit within tight volume constraints of existing filtration components. The contractor will establish preliminary design, performance and sizing of new filtration or filtration component concept to verify if the new design concept is feasible. Preliminary performance analysis, theoretical calculations, computational fluid dynamics (or equivalent) and initial lab evaluation will verify compatibility and commonality with current vehicle filtration systems. Design goals will be to provide a new filtration or filtration component concept that is adaptable, flexible and provides a direct replacement with current vehicle filtration system. As appropriate, a preliminary economic analysis will be performed to verify cost savings potential using the new filtration or filtration component concept. At the conclusion of Phase I the proof-of-principle must be demonstrated and enough evidence presented to verify the new filtration system design accomplishes its goals of: (1) improved service life/performance and (2) operation and support cost (OSCR) savings.

PHASE II: In Phase II the contractor's filtration or filtration component concept design or designs will be modeled and prototyped after performing additional theoretical analysis and computational fluid dynamics (or equivalent). If there happens to be more than one design concept, a trade-off analysis will be performed and the best design concept will be selected. The selected filtration concept design prototype will be up-dated and re-engineered prior to manufacturing the prototype parts and assembling the complete unit. Any changes to original prototype concept will be re-assessed to verify it meets performance objectives including service life improvements and reliability. The contractor will continue to harden the selected design concept by making design improvements which show improvements in performance and reliability which will be weighted against a required operation and support cost (OSCR) benefit to the affected military vehicle(s). Continued and repeated experimental evaluations of a full scale prototype will be conducted to demonstrate the reliability of the filtration concept design until the requirement goals are met. The contractor will also evaluate and study the new filtration prototype and consider manufacturing methods and innovations which could produce a new product with a projected design to cost equal to or better than current production filtration component it is replacing. Continued upgrades will be assessed to design harden the filtration or filtration component design concept so that it can withstand rigorous lab simulation tests depicting future field testing of the filtration prototype in Phase III. The Phase II prototype will demonstrate an increased technical capability verified by lab tests and technical assessment by contractor's cognizant technical experts in the field. At the conclusion of Phase II the contractor will deliver at least one (1) prototype filtration or filtration component.

PHASE III DUAL USE APPLICATIONS: Success of the program described above will lead directly to the military and commercial market. Cost savings are one reason for new technological products. Commonality between the Army's tactical wheeled vehicles and commercial wheeled vehicle is wide spread including the commercial Hummer and the military HMMWV. Also commonality exists between the M915/M916 Series Truck which is a commercial truck but bought by the Army with slight modifications for use in line-haul applications.

REFERENCES:

1) M915 Family of Vehicles (FOV) Purchase Description, requiring vehicle to be equipped with reusable/clean-able oil filter, Paragraph 3.7.1.7 in ATPDs 2286, 2289 and 2288.
2) Air Filter Element for HMMWV has a maximum dust capacity/service life requirement of only 16 hours. Minimum of 20 hours service life or more is desired.
3) HMMWV TM Manual limits Air filter specifies a maximum of three cleanings. Requirement exists for a new design air filter for longer service life.
4) Eleftherakis, John G., TITLED: Optimizing Automotive Transmission Filtration, SAE Paper 99PC-418, Dated 1998, Society of Automotive Engineers Inc., Warrendale, PA.


KEYWORDS: Filtration, Transmission Oil Filter, Engine Oil Filter, Engine Fuel : Filter, Engine Air Filter, Extended Service Life, Smart Fuel Pump

A03-232 TITLE: Point of Use Oil Quality Analysis

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: The Army's next generation of weapon systems and tactical vehicles will be designed and built to stringent requirements of efficiency, performance and reliability. Simultaneously, legacy systems need to be maintained in full operational condition with high availability at minimal operating cost. Total Operating Cost Reductions (TOCR) are being taken in every possible arena. As indicated by the Chief of Ordnance, one particularly burdensome program is the Army's Oil Analysis Program (AOAP). While its primary objective is to preclude readiness degradation, the current program suffers from excessive testing costs, a 95% return of normal oil condition result, a book keeping burden on the user units and the need to dispose of HAZMAT (HAZardous MATerial) contaminated equipment.

DESCRIPTION: The goal of the project is to develop a portable, self-contained analyzer that can be used at the vehicle with a minimal sample withdrawal. A control and logging capability inherent to the analyzer that could be tied to hood numbers would reduce the book keeping burden and be downloadable to the Army's computer network. Internal, self-calibration is a requirement. A secondary objective, more long term,would be to reduce the testing suite to an on-board system.

PHASE I: Evaluate the applications, existing designs, the state of micro and nano scale technologies available and requirements for improvements over current oil analysis tests. Determine the optimal design for independent operation based on current and emerging oil analysis technologies. Applicability to both commercial and military vehicles will be an important criteria in the design selection.

PHASE II: Design and build oil analyzers for the selected sub-tests. Characterize the combined oil analyzer performance in independent operation, document performance and demonstrate viability in a field environment. Reengineer where necessary to meet the defined performance objectives. The prototypes shall clearly demonstrate accuracy of analysis, robust operation and autonomous functionality for extended periods.

PHASE III DUAL USE APPLICATIONS: Next generation vehicles are a major research and development activity within the automotive industry. Oil analysis is used widely in the commercial sector. Any sensor and testing equipment developed for this program would have direct application in the broader, oil analysis market. The development, demonstration and integration of robust, economically priced, oil analysis equipments will be directly applicable to both the military and private sectors. By taking lessons learned from Phase II, the contractor will be able to manufacture a ruggedized design suitable for both military and commercial vehicles.

REFERENCES:
1. Manual on Significance of Tests for Petroleum Products; George V. Dyroff, Editor; ASTM Manual Series:MNL 1, Sixth Edition, ASTM PCN 28-001093-12, ISBN 0-8031-2050-8, 1993
2. http://books.usapa.belvoir.army.mil, Area Support Responsibilities 1.6.O Army Oil Analysis Program (AOAP).

KEYWORDS: Oil Analysis, AOAP, real time, lubrication, HAZMAT, green technology

A03-233 TITLE: <u>Advanced Military Diesel Engine Technologies</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: Stryker, PM

OBJECTIVE: The topic is to solicit advanced research and development with the objective to examine and develop technologies to increase fuel economy, increase power density with respect to volume and or weight, reduce specific heat rejection and provide RAM-D improvements for high output military vehicle and small stationary diesel engines.

DESCRIPTION: Anticipated future military FCS-type, high output vehicle engine operating conditions include cylinder heat loading greater than 4 HP per square inch (piston surface area), 4 cycle brake mean effective pressure exceeding 300 psia and brake specific heat rejection to coolant of 12 BTU per HP-Min or lower. Technology areas addressing these targets include: fuel injection system/combustion enhancement (technologies to be considered include ultra-high pressure injection or other combustion technologies enabling enhanced diesel combustion toward stoichiometric conditions without fuel economy degradation without increased smoke, and operation on heavy-hydrocarbon fuels including DF-2 and JP-8); and high efficiency broad range turbomachinery (military diesels require compact, high efficiency, broad range, low inertia devices that are tolerant to high exhaust pressure and temperature). Turbocharger and supercharger concepts that increase power density of small stationary power/auxiliary power units (up to 20 kW) and include relevant demonstration will be considered within this topic.

Technologies that address these military performance targets for FCS and encompass commercial applicability are desirable.

Engine RAM-D goal of 1000-hour life expectancy shall be pursued in all designs or concepts proposed. Also, concepts designs presented 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: Proof of concept with a relevant bench-test for proposed technology(s) is desirable for this initial phase.

PHASE II: Technology(s) should be experimentally demonstrated on a relevant power plant under various operating conditions.

PHASE III: Any demonstrated technology maybe applicable to both the military and commercial marketplaces and thus the appropriate applications should be targeted based on the concept.

REFERENCES:
1) Blue Ribbon Committee Report, "Research Needed for More Compact Intermittent Combustion Systems for Army Combat Vehicles", November 1995, DTIC No. A301691.
2) W. Bryzik, "Future Diesel Engines for Both Military and Commercial Engines", ISATA International Conference, Paper No. 97MOB028, 1997.

KEYWORDS: diesel, turbochargers, superchargers, high pressure injection

A03-234 TITLE: High Efiiciency, Compact Heat Exchanger for Mobile Equipment Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Brigade Combat Team

OBJECTIVE: The next generation of vehicles, tactical and commercial, may incorporate fuel cells, electric or electric– internal combustion hybrid propulsion systems, requiring complex control systems, and “drive by wire” auxiliary systems, each of which poses unique cooling problems and which will require improved heat exchanger technologies. The goal of this effort will be to develop a compact, cost effective, and efficient heat exchanger for small and confined space applications from vehicle cooling to cabin HVAC or accessory and electronics cooling. The program will take advantage of the emerging technologies in heat exchanger development including materials, configurations, and construction techniques.

DESCRIPTION: A study of current heat exchanger materials, construction, and configurations will serve as basis for potential applications of various system options that could benefit from emerging technologies. Based on evaluation of current heat exchanger performance and the processes used to create these products, the best available technologies will be identified and applied to create a specific heat exchanger for the target application..

PHASE I: Evaluate the applications, existing designs and technologies available, and requirements for improvements/innovation in current heat exchangers. Determine the optimal design based on current and on emerging heat exchanger technologies. Validate the selection through computer simulation and modeling. Applicability to both commercial and military vehicles will be an important criteria in the design selection.

PHASE II: Design and build heat exchangers for the selected application(s). Characterize the heat exchanger performance, install in the system, and document the heat exchanger performance in the application. Reengineer where necessary to meet the defined performance objectives. The prototypes shall clearly demonstrate increased performance capability and efficiency for the selected application, including electrically powered accessories.

PHASE III DUAL USE APPLICAITONS: Next generation vehicles are a major research and development activity within the automotive industry. The development, demonstration, and integration of robust, space saving, economically priced, high performance heat exchanger technologies into electric and hybrid-electric vehicles will be directly applicable to both the military and private sectors. By taking lessons learned from Phase II, contractor will be able to manufacture a military ruggedized design suitable for military vehicles.

REFERENCES:
1) T. G. Gonda, et. al. "MuSES: A New Heat and signature Management Design Tool for Virtual Prototyping." Proceedings of the Ninth Annual Ground Target Modeling & Validation Conference, Houtghton, MI, August 1998.
2) Thermal Modeling of Exhaust System Isolators, Fluent Newsletter Vol 10, Issue 2, Winter 2001.
3) A. R. Curran, et al. "Automated Radiation Modeling for Vehicle Thermal Management", 1995 SAE International Congress & Exposition, Exhaust Systems & Shielding session, Paper Number 950615, Detroit, MI, February 1995.

KEYWORDS: Heat exchanger, new materials, new design, militarized, thermal management.

A03-235 TITLE: Next Generation Thermal Management Rapid Prototype Tool for Future Combat Systems (FCS) and 21st Century Truck

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Future Combat Systems

OBJECTIVE: To research, design, prototype, and demonstrate an innovative next generation thermal management design tool applicable for the Army's Future Combat Systems, the 21st Century Truck, Air Force, and Navy systems as well as commercial vehicles. The rapid prototyping tool will eliminate the need for meshing commercial geometry by working on solid elements or, if need be, to automesh a commercial geometry maintaining all material properties for a full 3D thermal model with little to no preparation time required.

DESCRIPTION: The effectiveness of thermal virtual prototyping tools is reaching a limit. While vehicle designers in industry and in the military have some valuable tools available for designing both standard diesel and the newer hybrid electric vehicles, there still exists a bottleneck in moving from the designer's CAD geometry into the thermal analysis and management tools. Currently, a design engineer must take the CAD geometry for a vehicle and convert it into a surface mesh before it can be thermally analyzed. This process can be painstaking and lengthly and can require a good deal of expertise. This act contradicts the very idea of "rapid" in rapid prototyping. Commercial and the military engineers require a design tool that predicts temperatures and radiances without meshing--or at a minimum an auto-meshing capability that retains thickness and material properties. If there must be a need for meshing, it should not require a high quality mesh, instead a low quality mesh should suffice (i.e., one that allows for disjoint meshes and face conduction). In addition to reducing prep time, this improved vehicle rapid prototype tool should give the user the flexibility to tailor the calculation of radiation view factors (a serious problem in the engine compartment) which takes considerable run time and if possible only run view factor calculations when specific geometry has changed or when parts have been articulated (moving parts--which would change view factors). One way to accomplish this might be to have the solver become a user defined solver in a commercial code such as Pro/E Mechanica.

PHASE I: This phase will investigate innovative approaches to eliminating the need for a mesh in automotive thermal virtual prototyping—exploring meshless or automeshing techniques using with a commercial CAD package as the source of geometry. A requirements document and implementation plan will be developed for execution and proof of concepts will be demonstrated.

PHASE II: This phase will implement the inventive solver from the plan outlined in Phase I. A demonstration of the capability will include a typical full ground combat vehicle system including internals, such as propulsion system, auxiliary power units and wheels and/or tracks. This phase will demonstrate the feasibility of reducing the time needed to prepare commercial CAD geometry for thermal prediction, by using an innovative approach to creating a thermal model from commercial geometry and by using the innovative solver to obtain results.

PHASE III DUAL USE APPLICATIONS: This highly innovative tool would be invaluable to the commercial and military market and Phase III dollars from the FCS program are assured. Since the currently available tools, that rely on meshes have already been commercially successful, this next generation tool has a built-in market in the auto companies, DoD acquisition system designers (such as FCS contractors), Air Force training programs, the 21st Centry Truck plus any industry interested in thermal management.

REFERENCES:
1) PITAC - Report to the President Information Technology: Transforming our Society, Chapter 1.7 Transforming How We Design and Build Things,
"High-end computing technologies are needed for concept design, simulation, analysis with interactive control and computation steering, the mining of archived data, and the rendering of data for display and analysis." 2) Army Science and Technology Master Plan: (http://www.saalt.army.mil/sard-zt/ASTMP01/astmp01.htm) STOs III.GC.2000.03—Future Combat Systems (FCS) , III.GC.2001.01—Signature Management for Future Combat Systems, III.GC.1996.01—Ground Propulsion and Mobility.
3) "Modeling, material, and metrics: the three-m approach to FCS signature solutions", T. Gonda, et al, Proceedings of SPIE conference on Aerospace Sensing, Orlando 2002 (gondat@tacom.army.mil).

KEYWORDS: Signature management, signature reduction, automotive exhaust, ground vehicles, thermal management, thermal modeling, CFD, automesh, meshing, CAD

A03-236 TITLE: MEMS Smart Battery Monitoring System

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Brigade Combat Team

OBJECTIVE: To develop a miniaturized battery monitoring system applicable to commercial and military vehicle batteries utilizing Miniaturized Electro-Mechanical Systems (MEMS) Technology.

DESCRIPTION: With the ever expanding hybrid electrical propulsion systems designs for vehicles, the electrical vehicular battery, the "heart" of the system, has become the critical item in the development of the systems. As a result, obtaining optimal performance from the vehicular batteries has become of paramount importance. To facilitate the availability of the optimal performance, several efforts have been exerted in designing a battery monitoring/management system. However, all of these systems rely on popularly available technologies and result in systems that do not lend themselves to "seamless" integration into the batteries due to their size.
This effort will result in the development of a miniaturized battery monitoring/management system that will be small enough to be installed in vehicular batteries without adversely affecting their performance or increasing the size of the battery. The new MEMS based system will be capable of measuring all cell voltages, via a single signal conductor, battery temperature, and battery current, filtering and reducing the data in real time, storing the data and making it available by wireless communications. As a minimum, the system will include determination of the state-of-charge, status of the internal resistance, indication of electrolyte loss, and indication of permanent capacity loss of the battery through out the life of the battery. An added bonus would be for the system to be expandable and software reconfigurable, to support other, non-electrical, systems such as transmissions, trans axles, etc

PHASE I: Establish the feasability to transform the battery controller into an MEMS type syste, with corresponding production cost savings. Determine the extent to which parts of the system can be mimiturized and integrated into a single chip. Define the software task and layout of the software flow and task distribution among the various elements of the system and determine programming environment. Design definition of voltage and temperature sensors of the single wire signal as a single wire chip that can easily be attached at arbitrary locations in the battery, to the single wire. Integrate control and data aquisition functions into a single chip.

PHASE II: Establish technical resoources for the development and prototype production of the chip, develop a detailed management plan and define and design the test environment for the system. Design, develop and produce a fully functional prototype system, establish resources necessary for mass production and establish industrial partners for the distribution of the system on commercial markets.

PHASE III DUAL USE APPLICATION: Next generation vehicles are a major research and development activity within the automotive industry. Two of the more promising concecepts being explored are the hybrid and the electrical power packs. The most important component of both these systems is the power/energy storing device - the battery. To achieve optimum performance, a battery management system is required. The battery monitoring system developed under this project will become a core component of battery management systems for military and commercial vehicles, as well as the automotive industry, applications.

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1) Nowak, Dieter,"Pulse charging recombinant lead-acid batteries with variable frequency tied to the state of charge",Labat '93,Proceedings of the International Conference on Lead-Acid Batteries ,Varna, Bulgaria,07-11 June, 1993.

2) Schoener, Hans-Peter,"Monitoring of the state of the battery using the voltage response on drive currents", Proceedings of Drive Electric Conference, Sorrento, Italy,1985.

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KEYWORDS: MAMS technology, power managemen, battery management, transparent and nonintrusive miniturised application.

A03-237 TITLE: Heavy Duty Vehicles Cold starting System

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Brigade Combat Team

OBJECTIVE: To develop a cold starting system capable of starting heavy duty vehicles (such as the M 915 military vehicle) down to minus 40 degrees Fahrenheit, without external assist equipment.

DESCRIPTION: The standard military SLI battery, the 6 TMF battery, was designed as a dual purpose battery - to deliver maximum energy (for operating on board electrical components) and maximum power (for starting the vehicle engine). As such, these requirements are, basically, self-excluding, i.e., batteries can be designed for either maximum power or maximum energy. Therefore, the military battery was designed as a compromise, to be able to deliver power for starting engines with some energy delivering capability for the electrical requirements. This design has served the Army well in the past. However, with the advent of the Digitized Battle Field capability and the ever expanding vehicle "silent watch" requirements, the current battery systems in military vehicles are unable to adequately support all weather vehicle operations. One possible solution would be to develop a vehicle "power" system utilizing batteries designed for maximum energy delivery, such as "traction" type batteries, Valve Regulated Lead Acid (VRLA) batteries, both Absorbed Glass Mat (AGM) and GEL batteries, and Ultra Capacitors for the vehicle starting requirements, satisfying the maximum power requirements. This project will design, build, and validate such a system for starting heavy duty vehicles (such as the M 915 military vehicle) down to minus 40 degrees Fahrenheit.

PHASE I: Baseline current vehicle starting system for a selected heavy duty military vehicle. Determine requirements for an improved, optimized dual electrical starting system, for maximum power and maximum energy delivery. Review potential technologies for optimization of the new system. As a minumum, evaluate all current and near term available battery designs and chemistries, ultracapacitors, fuel cells, and 42 Volt electrical systems for vehicles. Define the new system and develop a model for it. Demonstrate the model validating potential improvements.

PHASE II: Build the new system, test and validate its improved performance in a laboratory environment. Based on testing results, redefine the systtem and build a new system. Demostrate the performance of the new system on a selected heavy duty application vehicle, test and validate improvements. Define the effectiveness of the new system and upgrade the model. Define the cost of the system and identify potential improvement technologies. Perform producibility study.

PHASE III DUAL USE APPLICATION: Next generation vehicles are a major research and development activity within the automotive industry. The development, demonstration, and integfration of of a robust, space saving, economically priced high performance vehicle cold starting system into hydrocarbon fuel, hybrid, and electrically powered vehicles will be directly applicable to both the military and private sector.

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1) GM, 6.2 L IDI Engine Heat Rejection Comparison, 1984.
2) SwRI test, Non-aqueous Propylene Glycol Coolant in 6.2L Engine.
3) TARDEC Technical Report No. 13675, TITLED: Lab Test of Prototype Quick Switch Modular Core Radiator for M809 Series 5 Ton Truck, DATED Dec1995, CONTRACTOR: U. S. Army Tank-Automotive Research, Development, and Engineering Center (TARDEC).


KEYWORDS: Valve Regulated Lead Acid batteries, Nickel Metal Hydrd batteries, Lithium Ion bastteries, fuel cells, ultracapacitors, 42 Volt electrical systems.

A03-238 TITLE: Low-Power, Compact Logistic Fuel Pre-Reformer

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM-LTV

OBJECTIVE: To develop a pre-reformer technology that will both vaporize and partially decompose logistic fuels for use with fuel cell reformers. Military logistic fuels pose siginificant problems for use with fuel cell systems due, in part, to their heavy aromatic content and wide boiling point distribution. The heavy compounds in the fuel tend to form coke when processed in high temperatue, lean unit operations such as a partial oxidation reformation process. By partially decomposing or cracking the fuel prior to a reformation process the coke formation problem may be mitigated. Also there are potential secondary benefits for spark ignited, logistic-fueled internal combustion engines; fuel-fired portable heaters for shelters, personnel and utility heating; field kitchen equipment; and for engine cold-weather starting aids. Automatically included are any other military applications characterized by steady combustion or combustion-like processes (ref. fuel cell reformers), problems with attaining reliable starts after long periods of non-use, cold weather starting difficulties and potential for coke formation due to poor fuel-air mixing.

DESCRIPTION: The pre-reformersystem should be low power-consumption, reliable after long periods of non-use, reliable and durable in automotive temperature and vibration environments, compact, light weight and low-cost. It must operate in a manner that strongly deters byproduct coke formation in fuel cell reformer and fuel-fired heating systems. It must tolerate variations in logistic fuel composition, particularly sulfur content. The fuels of primary interest are JP-8, JP-5, Jet A, Jet A-1, DF-2, DF-1 and low-sulfur commercial diesel fuels.

PHASE I: Baseline fuel decomposition pathways for fuels of interest, with added emphasis on requirements for fuel cell reformer applications. Establish the strengths and weaknesses of current atomization and vaporization systems. Demonstrate, under laboratory conditions, technology that provides superior capabilities, with realistic potential for improved reliability and durability under automotive conditions. Define new system that will process approximately 6 pounds per hour of logistic fuel, and provide preliminary estimates of weight, cost and power consumption.

PHASE II: Design and build a demonstrator of the system developed in Phase I, test and validate its improved performance in laboratory environment. Based on test results, refine the system and build an updated version. Demonstrate the upgraded system under laboratory conditions that verify its improved capability versus present systems. Demonstrate the system with an actual or simulated, fuel cell reformer, working in cooperation with a fuel cell reformer developer that is acceptable to the Government. Perform a full mass and energy balance analysis around the demonstrated unit operation. Define the cost of the system and identify potential improvement technologies.

PHASE III DUAL USE APPLICATIONS: Logistic fuel pre-reforming systems for fuel cells; liquid-fueled heating equipment, including kitchens, furnaces, and space heaters for vehicles, shelters and personnel. Fuel-burning industrial dryers. Fuel-air mixture preparation for spark-ignited, logistic fuel internal combustion engines.

REFERENCES:
1) Larmine, J. Dicks, A. Fuel Cell Systems Explained, John Wiley and Sons, 2000.
2) Heywood, J., Internal Combustion Engine Fundamentals, McGraw-Hill 1988.

KEYWORDS: Logistic fuel, JP-8, Vaporization, Fuel cell, reformer

A03-239 TITLE: Development of An Underarmor 10 Kilowatt Thermoelectric Generator Waste Heat Recovery System for Military Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM BCT, and PM FCS

OBJECTIVE: The objective of the project is to develop a 10 kilowatt thermoelectric generator (TEG) waste heat recovery system for U.S. ground military vehicle systems that would have the added benefit of significantly reducing the temperature of the exhaust. Targeted exhaust output temperatures should be 50% lower than current exhaust temperatures. Aside from typical diesel internal combustion engines, the proposal should also focus on the concept of a waste heat recovery system on fuel cell propulsion systems and the Abrams turbine engine. Future military propulsion may utilize fuel cell technology. The problem with fuel cells is that 80% of the heat must be ejected through the radiator. Concepts specifically for the Abrams tank should focus on the development of a 20 kilowatt thermoelectric generator (or greater), due to the significant amount of available heat. If additional power is not needed, an additional benefit is the power required for the alternator is eliminated and this power is available for other purposes. Systems that would benefit the most include the FCS, Stryker, FSCS, Abrams tank, trucks, and LAVs. The final size of the thermoelectric generator should be less than 0.5 cubic meters. Concepts by the offerors should include the possibility of the thermoelectric generator serving the added purpose of a 10 kilowatt auxiliary power unit (APU). This APU should demonstrate a significantly lower noise and thermal signature than current APUs. The thermoelectric generator APU must use a fuel that would require no additional logistical support. Offerors must include estimates on how much noise, in decibels, the TEG will produce and the temperature output from the thermoelectric generator APU. The engines utilized for a baseline include the Stryker Caterpillar 3126 model engine and the Abrams 1500 turbine engine. The main focus should be on the Stryker engine since the Abrams is the only ground combat system that utilizes a turbine engine. The Stryker exhaust temperature is estimated at 148 degrees Celsius and the Abrams exhaust temperature is approximately 537 degrees Celsius. Information regarding exhaust temperatures and flow rates will be updated in this SBIR before solicitation. With regard to weight, the weight of the TEG should be less than current alternator and APU systems combined. The offeror must also consider how battle damage will impact the performance of the unit.

DESCRIPTION: The FCS, Stryker, and Abrams tank will be the key components of the Army's leading-edge battlefield systems as it enters the next century. All of the systems rely heavily on electronics to provide them with battlefield superiority and demand for on-board electrical energy is expected to continue to increase. The thermoelectric generator will provide additional power without any additional fuel consumption. To keep these electronics functioning while the engine is not running, an auxiliary power unit is utilized. One primary purpose of using the APU is to reduce fuel consumption and the wear and tear on the main engine. For some military systems, such as the Stryker, FCS, Future Scout, Abrams Tank, and LAV, the APU will serve another critical purpose. This is to limit the detectability, specifically the noise and thermal signature of the system while in combat. Typical auxiliary power units are powered by diesel piston engines that produce a significant amount of noise and heat. A fuel cell APU may have some of these benefits, but heat will still be a problem. Molten carbonate electrolyte systems and solid-oxide electrolyte systems have higher operating efficiencies and reduce or eliminate the need for expensive catalysts, but these fuel cells have operating temperatures of 600 and 1000 degrees Celsius respectively. The thermoelectric generator can, in essence, eliminate the noise signature and potentially reduce the heat signature to a level that can be more easily managed by normal survivability countermeasures.

Many modern high tech munitions use infra-red sensors to detect engines. This makes diesel engine propulsion equipment, and especially the Abrams tank, susceptible to new infra-red mortar rounds and heat-seeking top-attack ATGMs like Javelin. With the Stryker exhaust out the top of the vehicle, the detection and destruction of the Stryker may be a huge concern. Specifically, the Abrams engine heat causes problems in tank/infantry tactics against fortified areas and in urban terrain. DARPA, Department of Energy (DOE), Naval Research Laboratory, and the California Energy Commission are currently funding research and development of thermoelectric generators. Most of the development is in the range of microwatt to a kilowatt generator. Specifically the DOE and the California Energy Commission sponsored the development of a 1 kilowatt TEG waste recovery heat system that was installed on a truck. Currently PACCAR is sponsoring this development and testing is being conducted at a PACCAR test facility.

Technological advancements will allow for a much more efficient system than the one developed with DOE funding. Current technology is approximately 5% efficient while technological advancements in recent years will allow for an efficiency of approximately 20 to 25%.

With regard to application to the commercial market, there is significant interest in this technology by the trucking industry. This includes power generation as well as potential to reduce emissions with this technology. The worldwide increase in fossil fuel consumption, especially oil, and the increase in pollution concerns has prompted many governments to discourage high consumption by leveraging taxes on fuel and regulations requiring the auto industry to continuously improve fuel economy and reduce pollution as well. This has resulted in worldwide efforts to develop hybrid (conventional gasoline/diesel internal combustion engine & electric motors) systems and fuel cell technology to reduce fuel consumption and emissions. Hybrid vehicles are currently being developed by Honda and Nissan and interest is building. The usage of a thermal electric generator may be able to recoup up to 20% of the energy that would be wasted through the emissions. This could significantly improve the overall efficiency of a hybrid system and help this technology to penetrate the market quicker. Also, there is growing interest in the trucking industry for additional power sources.

PHASE I: Develop a 10 kilowatt thermoelectric generator concept. This concept should address how this conceptual TEG can be integrated into production for the targeted systems. The offeror should include estimates for temperature output from the TEG. Any estimates regarding application to an auxiliary power unit should focus on the Stryker vehicle. The offeror should also provide a feasibility study through analysis and possibly scaled testing.

PHASE II: Design and develop two 10 kilowatt thermoelectric generators, based upon the concepts identified in Phase I. This thermoelectric generator will undergo testing to verify performance capability and accelerated life testing. In addition, the thermoelectric generator is to meet the requirements outlined in the description. Note that any testing will be customer funded and validation testing will only be conducted in phase III.

PHASE III DUAL USE APPLICATIONS: The FCS, Brigade Combat Team, M109, and PM Abrams have expressed interest in this technology. Currently, the Department of Energy (DOE) and California Energy Commission have sponsored a 1 kilowatt thermoelectric waste recovery generator for a class 8 diesel truck. In addition, DOE and Kenworth are sponsoring development of a 3 kilowatt thermoelectric waste heat recovery system. Research and development of thermoelectric generators for the government have also focused on a milliwatt modules for MAVs (micro airborne vehicles) – DARPA funding, milliwatt module for sensors – Navy, small generators for Picatinny Arsenal, and milliwatt programs for space exploration.

REFERENCES:
1) John C. Bass, Aleksandr S. Kushch, Norbert B. Elsner. June 2001. Thermoelectric Generator (TEG) for Heavy Diesel Trucks. 20th International Conference on Thermoelectrics, Beijing.
2) Aleksandr S. Kushch, John C. Bass, Saeid Ghamaty and Norbert B. Elsner. August 2001. Thermoelectric Development at Hi-Z Technology Diesel Engine Emission Reduction Workshop, Portsmouth, Virginia.
3) Saeid Ghamaty, Norbert B. Elsner and John C. Bass. September 1999. Development of Quantum Well Thermoelectric Device 18th International Conference on Thermoelectrics. Baltimore .
4) J. C. Bass, N. B. Elsner and F. A. Leavitt. 1994. Performance of the 1 kW Thermoelectric Generator for Diesel

Engines. 13th International Conference on Thermoelectrics, Kansas City.
5) Dr. Rudy Buser. Power Management for the Army. U.S. Army CECOM RDEC Center http://www.dtic.mil/ndia/future/buser.pdf
6) Donald Fink, Donald Christiansen. Electronics Engineer's Handbook 3rd edition, 1989.
7) http://www.globalte.com/main.htm
8) http://www.eyeforfuelcells.com/ReportDisplay.asp?ReportID=1368
9) http://www.sae.org/automag/techbriefs/04-2002/
10) http://www.sae.org/automag/features/fuelcells/fuelcell7.htm
11) http://www.globalte.com/releases.htm

KEYWORDS: thermoelectric generator auxilary power unit apu waste heat recovery system

A03-240 TITLE: Water Production for Tactical Systems

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop a lightweight, compact, energy efficient technology to purify water that can be embedded into tactical systems including the soldier system. The technology must be able to achieve 6 log reduction of bacteria, 4 log reduction of viruses and 3 log reduction of protozoan cysts. It is desired that the system be able to produce water meeting the Tri-service drinking water standards described in Technical Bulletin (TB) Medical (MED) 577.

DESCRIPTION: The Army has a need for a water purification technology that can be embedded into tactical systems with performance that is superior to currently available technology. The individual solider requires 1.5 to 3 gallons of drinking water per day to prevent dehydration depending on the environmental conditions. A 3 to 4% water deficit (2-3 quarts) significantly reduces a soldier's performance (up to 48%) and a 6 to 8% deficit renders a soldier completely ineffective. Therefore, the soldier must carry 12 to 24 pounds of water per day of mission duration or rely on daily resupply through the sustainment system. If the sustainment system is unable to provide the soldier with the required quantity of water the soldier may be forced to drink locally available water risking disease and death. The water, often including tap water, may be unfit for consumption due to pathogenic organisms and high levels of suspended solids. An embedded purification technology would reduce the logistics footprint of the force and ensure soldier readiness and safety when cut-off from lines of supply. The proposed water purification technology will protect the soldier against naturally occurring pathogenic organisms as well as weaponized versions and suspended materials allowing the soldier to take advantage of any locally available water source. The reduced demand for water distribution will reduce the projected daily sustainment requirement of the force by 20 to 40% improving sustainability and enhancing agility while protecting the soldiers against natural, military, and terrorist waterborne threats to the soldiers safety and readiness.

The goal of this project is to develop a water purification technology that may be embedded into tactical systems including the soldier and vehicle systems based on separation technology that is superior to current state-of-the-art hand-held water purification technology. This production technology must be lightweight, compact, and remove turbidity, bacteria, viruses and protozoan cysts from natural source waters without the addition of chemical disinfectants. The technology must be capable of disinfecting and/or removing microbiological contaminants to levels as stated by The EPA Guide Standard Test Protocol for Microbiological Purifiers, bacterial removal to 6 logs, protozoan cyst removal to 3 logs, and viral removal to 4 logs. The product must also produce at least 150 liters of potable water before maintenance or the need for replacement parts. Consideration will be given toward the removal of chemicals identified in the military drinking water standards (TB Med 577) to below required levels. The device must reduce turbidity (below 1 ntu), and produce at least 1 liter per minute, and weigh less than 18 ounces.

PHASE I: Conduct analytical and experimental laboratory studies demonstrating proof of separation concept. Demonstrate feasibility for the purification of drinking water in a laboratory environment, including low fidelity integration of any components to establish that pieces will work together. Timeline to complete Phase I is 6 months (threshold) to 10 months (objective) with an expected level of maturity of TRL 4.

PHASE II: Develop conceptual device designs, asses designs, and perform analysis to predict device behavior and efficiencies. Select application/design for prototype development. Conduct sub-component design, fabrication, and testing for critical components and subassemblies. This phase would include the integration, assembly, and performance testing of a breadboard or prototype water purification device. Testing in a simulated environment should be robust enough in this phase to assess performance, capability, durability, and capacity of water purification devices to the TRL 5 level.

PHASE III: Based on the Phase II results a prototype near or meeting the planned operational specifications will be designed, fabricated and demonstrated in a relevant environment. Testing should be robust enough in this phase to validate performance, capability, durability, and capacity of water generation devices to the TRL 6 to 7 level. Commercialization partners and plans will be developed and the manufacturing plan will be established. The technology has a significant potential for dual use military and civilian applications. These devices would have a broad range of military and civilian applications where contamination of water sources is a concern. This includes all army water purification systems and may be applicable to emergency response agencies, agencies responsible for countering terrorist threats, and organizations that operate in unstable regions. Potential technologies may also be effective against pesticides and herbicides found in water sources and therefore, are of interest to backpackers, outdoorsman, and homeowners in regions where this type of contamination has been identified. Commercial development, marketing, and sales of this technology would reduce the cost and enhance the availability of the item for the military.

REFERENCES:
1) Bagwell T. H., Shalewitz B., and Coleman A., "The Army water supply program: An overview," Desalination, v99, p409-421, 1994.
2) Directorate of Combat Developments for Quartermaster (DCDQM), www.cascom.lee.army.mil/quartermaster
3) FM 10-52, Water Supply In Theaters of Operation, 1990 (see DCDQM website).
4) FM 10-52-1 Water Supply Point Equipment and Operations, 1991 (see DCDQM website).
5) U.S. Army Functional Concept For Potable Water Support (see DCDQM website).
6) Potable Water Planning Guide, 1999 (see DCDQM website).
7) U.S. Army Center For Health Promotion and Preventative Medicine (CHPPM), http://chppm-www.apgea.army.mil
8) TB Med 577, Sanitary Control and Surveillance of Field Water Supplies (see CHPPM website).
9) TRADOC Pam 525-66, Future Operational Capability, 1997, 1999, FOC QM97-003, QM99-003, (www.tradoc.army.mil).

KEYWORDS: Water Purification, chemical and biological agent removal

A03-241 TITLE: Innovative Wet Gap Crossing Technologies for the Future Combat System/Objective Force (FCS/OF)

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM Bridging

OBJECTIVE: To provide the Future Combat System/Objective Force (FCS/OF) with the technology to cross non-fordable wet obstacles of indefinite length. Current wet bridging systems are not transportable in C-130 aircraft, which is one of the key performance parameters of the FCS/OF. The proposed program shall yield innovative wet gap crossing technology, transportable in C-130 aircraft. In summary, the objective of this effort is to provide the FCS/OF the tool to maintain its operational mobility and combat effectiveness across wet gaps (1).

DESCRIPTION: Wet Bridging Technology for the FCS/OF: Current wet bridging equipment, the Standard Ribbon Bridge (SRB) (2) and the soon to be fielded Improved Ribbon Bridge (IRB), comprise folded pontoons, which are transported and launched/retrieved by the Common Bridge Transporter (CBT). The unfolded pontoons are assembled and maneuvered by powered Bridge Erection Boats (BEB), also transported by the CBT. Both the SRB and the IRB are bulky and do not meet the key performance parameter (KPP) of the FCS/OF for transportability in C130 aircraft (1).

The FCS/OF will be comprised of a new family of vehicles weighing 16 – 18 Tons, including payload. In contrast, the SRB/IRB pontoons respectively weigh 6 – 7 Tons and the CBT without any payload weighs 20 Tons. The challenge is to provide wet gap crossing capability to the FCS/OF using the new family of vehicles that will weigh only 16 – 18 Tons, including payload. To maintain the momentum of advance, the FCS/OF will require wet gap crossing equipment that can quickly be deployed across non-fordable water obstacles of indefinite length. It should also be possible to construct rafts using the gap crossing equipment. Last, individual modules of the FCS/OF wet gap crossing system should be capable of being air transported and dropped in the wet obstacle, by a CH47 helicopter. Innovative solutions are sought to provide rapid wet gap crossing capability to the FCS/OF.

The bridge, when deployed, shall be capable of carrying Military Load Classification (MLC) 30 loads for normal crossing and MLC 40 loads for caution crossing (4). The proposed innovative bridging technologies shall meet all requirements of the Trilateral Code Design and Test Code for Military Bridging and Gap-Crossing Equipment (4).

PHASE I: Develop system level concepts for wet gap crossing technologies for the FCS/OF. Evolve and develop novel launching solutions for non-fordable wet gaps of indefinite length. Perform simulation, analyses and design studies for launching and load carrying capacity. Threshold load carrying capacity shall be MLC 30 for normal crossing and MLC 40 for caution crossing. Perform analyses to determine the maximum MLC load (compared to the threshold) sustainable by the bridge while still meeting the weight and packaging constraints. Desirable load carrying capacity is MLC 65. Analyze aerodynamic effects when the system is being air transported by a CH-47 helicopter. Analyze packaging of system for C-130 aircraft loading and unloading and transportability. Make recommendations as to the most promising concepts for wet gap crossing technology for the FCS/OF. Deliver interim reports after 2 and 4 months and final report 6 months after contract award.

PHASE II: Design, develop and demonstrate through tests on breadboard models, critical components, critical modules, critical kinematic mechanisms, etc. Use innovative modeling and simulation techniques to reduce the design and testing time. Design, develop and fabricate representative prototype modules that can be assembled to form a raft capable of carrying the designed MLC loads.

PHASE III DUAL USE APPLICATIONS: Due to the constraints of extreme light weight as imposed by the FCS/OF bridging requirements, it is envisaged that this SBIR will result in innovative designs using advanced composites. Composites are increasingly finding applications in infrastructure highway bridges and many other civil engineering applications. Furthermore, it is expected that this SBIR will result in novel watercraft/pontoons, which can be packaged for C-130 aircraft transportation. This novel watercraft technology should find applications in the commercial watercraft and the water sports industries.

REFERENCES:
1) Operational Requirements Document (ORD) for the FCS, January 2003.
2) Jane's Military Vehicles and Logistics, 23rd Edition, 2002 – 2003.
3) Information Brochure on REBS: Available on request from POC.
4) Trilateral Design and Test Code for Military Bridging and Gap Crossing Equipment, January 1996.

KEYWORDS: FCS/OF, Military bridges, Mobility.

A03-242 TITLE: The Robotic Mule

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The objective of this SBIR topic is to build a legged robotic Mule for troop support and payload carrying.

DESCRIPTION: Robotics is an area of increased interest in the Defense community. With an increased reliance on robotic vehicles, alternate mobility mechanisms must be examined. On narrow mountain passes or heavily forested trails, there is no room to widen the wheelbase of a vehicle in order to increase stability under a payload. Because of the inherent high center of gravity of a quadraped or biped robot, legged robots are well suited to this task. When you think about it, the best way to increase payload on a narrow trail is to build a taller, not wider vehicle. The ability to adjust center of gravity and gait is key to a successful robotic "Mule."

PHASE I: This vehicle should be designed from the beginning with payload capacity in mind. A payload fraction of 25% should be a design goal. Phase I should investigate ways to adjust the gait and posture of the robot under heavy loading.

PHASE II: The final design will be built and tested in Phase II with a heavy emphasis on testing. It is the author's opinion that several changes will need to be made in control algorithms upon testing of the final design. That is why I suggest that final assembly of the prototype should occur approximately 3/4 of the way through Phase II.

PHASE III DUAL USE APPLICATIONS: While many commercial uses are available for a walking payload robot, probably the most viable would be in the toy and household markets. The government would greatly benefit from having a US commercial base in legged robotics, because right now, there is really only a base in Japan and Europe, greatly hindering our ability to develop cutting edge robotics. This is why we are very interested in partnering with industry to develop a core capability in the US.

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KEYWORDS: robotics, legged robotics, dynamic stability

A03-243 TITLE: Development of 15,000/30,000 BTU Multi-Fuel Fired Forced Air Heating System

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Medium Tactical Vehicles (MTV)

OBJECTIVE: The objective of the project is to develop a multi-fuel fired forced air heating system with heat outputs of 15,000 BTU (4.4kW) to 30,000 BTU (8.8kW) that take their combustion and ventilating air either from the same source (Single Air) or from different sources (Dual Air). The heating system to be developed must meet the performance requirements of MIL-PRF-62550D (AT) and Source Control Drawing 12474864. The heating system must provide crew cab heat at low arctic temperatures for military tactical and commercial vehicles utilized in extreme environmental and rugged conditions. The heating system must contain self diagnostics, operating mode codes, component failure codes, system faults, error codes and data codes which a conspicuously displayed to assist in troubleshooting and repair. To attain this goal and to meet size and space claim requirements, new manufacturing practices will be required as well and the development of new miniaturized components. To achieve these goals, advanced materials will be required for use that will drive new manufacturing technologies for hardware and electronic components.

DESCRIPTION: The project will be designed to prove out the technical objectives and capabilities of the system concepts, the manufacturing processes and the materials utilized. A work plan will be developed to perform surveys of components, manufacturing processes required and technologies anticipated for use in providing a preliminary design. The preliminary design will be reviewed in order to determine compliance with performance requirements of the specification and to ascertain the design's capability to meet all requirements of application. After the preliminary design review phase, a proof of concept will be performed to ensure that the heating system design in fact does meet all performance requirements specified. Throughout the process, it is anticipated that the contractor will provide day-to-day informal contacts with the government's appointed representative and will provide monthly technical progress reports, with a complete technical progress report provided at the end of each identified phase of the project.

PHASE I: Conduct an analysis of candidate vehicle requirements, existing system capabilities, and anticipated capabilities of the candidate replacement system. Produce a report and proposal for Phase II activities showing the feasibility of producing a heater that meets the requirements outlined in the SBIR (e.g. self diagnostics, operating mode codes, component fault/failure codes, can eliminate defrosting/heating problems on the FMTV, and meets the requirements of MIL-PRF-62550D).

PHASE II: Produce working pre-prototype systems that meet the requirements of the SBIR and MIL-PRF-62550D for evaluation in the FMTV truck. Test hardware. Document, summarize and deliver a written report on performance characteristics as compared to existing heating system used on the FMTV platform. Produce a commercialization plan.

PHASE III DUAL USE APPLICATIONS: The heating system could be used on a broad range of military tactical vehicles and civilian vehicles where a passenger heat source is required. Commercial applications could include semi-trucks, locomotive cabs, and construction vehicles such as dump trucks operating in Arctic and cold weather conditions.

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KEYWORDS: Heating System, Heat Source, Advanced Materials, Manufacturing Technology