Office Of The Secretary Of Defense (OSD)
Deputy Director Of Defense Research & Engineering
Deputy Under Secretary Of Defense (Science & Technology)
Small Business Innovation Research (SBIR)
FY2004.3 Program Description

Introduction

The Deputy Under Secretary of Defense (Science & Technology) SBIR Program is sponsoring two information systems technology themes in this solicitation: Trusted Circuit technology and Software Protection; two material technology themes: Corrosion Technology and Laser Materials; and the Energy & Power Technology. We are also co-sponsoring two additional technology areas, biomedical technology and information technology for military health systems, with Defense Health Affairs.

The Army, Navy and Air Force are participating in the OSD program this year. The service laboratories act as our OSD Agent in the management and execution of the contracts with small businesses. The service laboratories, often referred to as a DoD Component acting on behalf of the OSD, invite small business firms to submit proposals under this Small Business Innovation Research (SBIR) program solicitation. In order to participate in the OSD SBIR Program this year, all potential proposers should register on the DoD SBIR website as soon as you can, and should follow the instruction for electronic submittal of proposals. It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Website at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 1-866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The DoD SBIR Proposal Submission Website allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report.

We WILL NOT accept any proposals that are not submitted through the on-line submission site. The submission site does not limit the overall file size for each electronic proposal, there is only a page limit. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. If you wish to upload a very large file, it is highly recommended that you submit prior to the deadline submittal date, as the last day is heavily trafficked. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, the DUSD(S&T) SBIR Program will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector. Objectives of the DUSD(S&T) SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

Description of the OSD SBIR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to $100,000. We plan to fund 3 Phase I contracts, on average, and downselect to one Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund this many. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes technical performance toward the topic objectives and evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector, in accordance with Section 4.3.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal in addressing the goals and objectives described in the topic. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the DoD may award non-SBIR funded follow-on contracts for products or processes, which meet the component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be invited to submit a Phase II proposal. Invitations to submit Phase II proposals will be released at or before the end of the Phase I period of performance. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c. The potential for commercial (defense and private sector) application and the benefits expected to accrue from this commercialization.

In addition, the OSD SBIR Program has a *Phase II Plus* Program, which provides matching SBIR funds to expand an existing Phase II that attracts investment funds from a DoD acquisition program or Private sector investments. ***Phase II Plus*** allows for an existing Phase II OSD SBIR effort to be extended for up to one year to perform additional research and development. ***Phase II Plus*** matching funds will be provided on a one-for-one basis up to a maximum $250,000 of SBIR funds. All ***Phase II Plus*** awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a ***Phase II Plus*** contract modification.

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract (see the Fast Track Application Form on www.dodsbir.net/submission). Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals in an expedited manner in accordance with the above criteria, and may select these proposals for Phase II award provided: (1) they meet or exceed selection criteria (a) and (b) above and (2) the project has substantially met its Phase I technical goals (and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial products. Proposers are encouraged to obtain a contingent commitment for private follow-on funding prior to Phase II where it is felt that the research and development has commercial potential in the private sector. Proposers who feel that their research and development have the potential to meet private sector market needs, in addition to meeting DoD objectives, are encouraged to obtain non-federal follow-on funding for Phase III to pursue private sector development. The commitment should be obtained during the course of Phase I performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase II which if met, would justify non-federal funding to pursue further development for commercial purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General informational questions pertaining to proposal instructions contained in this solicitation should be directed to the topic authors and point of contact identified in the topic description section. Proposals should be electronically submitted. Oral communications with DoD personnel regarding the technical content of this solicitation during the pre-solicitation phase are allowed, however, proposal evaluation is conducted only on the written submittal. Oral communications during the pre-solicitation period should be considered informal, and will not be factored into the selection for award of contracts. Oral communications subsequent to the pre-solicitation period, during the Phase I proposal preparation periods are <u>prohibited</u> for reasons of competitive fairness. Refer to the front section of the solicitation for the exact dates.

Proposal Submission

Proposals shall be submitted in response to a specific topic identified in the following topic description sections. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the DTIC SBIR Interactive Technical Information System (SITIS).

It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Website at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The proposal submission website allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report. We **WILL NOT accept any proposals which are not submitted through the on-line submission site.** The submission site does not limit the overall file size for each electronic proposal, only the number of pages are limited. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

The following pages contain a summary of the technology areas, which are followed by the topics.

Information Systems Technology Area

1. Software Protection Technology

In December 2001, the Software Protection Initiative (SPI) was established to prevent the unauthorized distribution and exploitation of national security application software by our adversaries with the following goals: 1) slow the acquisition of high-value DoD software by our adversaries, 2) make cost-prohibitive the exploitation of DoD software when it does "leak", and 3) ensure that technology and policy protection measures are appropriately applied, balancing mission requirements with security.

The focus of the DoD Software Protection Initiative (SPI) is to improve protections for critical scientific, engineering, and modeling and simulation software running on desktops through supercomputers. This type of software represents a significant portion of DoD's intellectual property (IP) and enables the development of next generation weapon systems. The SPI will develop software protection technologies; support the insertion of these technologies into application software; and define tools and methods for protected development and distribution of application software. The SPI will compliment the DoD Anti-Tamper Program, which addresses protections on weapon system hardware, subsystem hardware, and embedded software.

The US Air Force will act as the Office of the Secretary of Defense (OSD) Agent in the management and execution of these topics and resulting contracts with small businesses. Proposals in response to these topics must be submitted electronically (see previous pages for details).

The Software Protection topics are:

OSD04-SP1 Attack Modeling Technology and Methodology
OSD04-SP2 Next Generation Software Reverse Engineering Tools
OSD04-SP3 Automated Tools for Software Protection Technology Insertion
OSD04-SP4 Polymorphic Software
OSD04-SP5 Behavior Based Malicious Logic Monitoring and Detection
OSD04-SP6 Code Pedigree, Code Integrity, Tamperproofing, Software Protection, Software Security
OSD04-SP7 Software Pedigree Analyzer

2. Trusted Circuit Technology

Many emerging DoD systems employ non-commercial off-the-shelf (COTS) custom-fabricated integrated circuits (ICs), such as application-specific integrated circuits (ASICs), field programmable gate-arrays (FPGAs), and system on a chip (SoCs). Such circuits are vital to basic functionality and performance of modern DoD systems. However, in general, the users of such ICs have no way to ensure that the behavior of these ICs conforms to system requirements and advertised design specifications. In particular, it is difficult or impossible for users of ICs to establish trust that the ICs faithfully implement design specifications, vice other (possibly malevolent) behaviors. It is crucial for DoD users to establish the trustworthiness of ICs in deployed systems, so that such systems are not advertently or maliciously compromised. The objective of this topic is to develop enabling technologies to verify the correctness, reliability, and functionality of ICs after fabrication, i.e., to enable users to trust the ICs they employ.

DARPA will act as the Office of the Secretary of Defense (OSD) Agent in the management and execution of this topic and resulting contracts with small businesses. Proposals in response to this topic must be submitted electronically. The topic is titled: OSD04-TC1 Technology for Trusted Circuits.

Materials/Processes Technology Area

1. Corrosion Prevention and Control Technology

The Department of Defense is interested in broad-based innovative research that addresses DoD-wide problems and issues related to corrosion prevention and control. Major themes associated with this SBIR Corrosion Initiative include:

- Innovative research in advanced sensors and corrosion control techniques applicable to Defense systems and facilities.
- Innovative research in methodologies and data mining techniques to assist in the estimation of corrosion cost both the total cost of corrosion and, more importantly, preventable or reducible costs.
- Innovative research in models that can predict the impact of new materials, coatings, processes, etc in complex systems, such as aircraft, ships, ground vehicles, facilities and the performance of materials and material systems in the unusual and often highly aggressive environments in which Defense systems must operate or Defense facilities must be located.
- Innovative research in advanced corrosion-preventative coatings and repair materials with wide DoD applicability.
- Innovative research in defining, measuring, and predicting the corrosivity of environments, especially environments of significance to DoD operations and materiel storage; e.g.; dry, erosive desert operations; intermittently wet, erosive environments; marine environments associated with materiel transport and storage; tropical and sub-tropical operating and storage environments.

The following seventeen (17) specific topics are included in the initiative addressing the above themes:

OSD04-C01 In-Situ Smart Corrosion Sensors for Water Piping Systems
OSD04-C02 Investigation of Electrophoresis as a Novel Coating Mechanism for Sealing Concrete
OSD04-C03 Corrosion Prevention of Steel Reinforcements in Concrete in Bridge Decks and Piers, and Structures Through Electrokinetic Control of Chloride Ion Migration
OSD04-C04 Smart Self-Healing Nanotechnology Coatings
OSD04-C05 Concrete Admixtures that Defend Against Salt Scaling and Freeze-Thaw
OSD04-C06 Development of a Crack Resistant Durable Concrete Repair Material for Navy Concrete Structures
OSD04-C07 Embrittlement Fuse to Detect the Presence of Hydrogen Assisted Cracking (HAC) Effects in High Strength Materials
OSD04-C08 Sensors for the Automation of Biofouling Control
OSD04-C09 Model Corrosion Protection System Breakdown Utilizing Existing Data
OSD04-C10 Development of Corrosion Test to Predict or Rank Corrosion Performance of Current and Novel Corrosion Inhibiting Sealants, Both Conductive and Non-Conductive, in Aggressive Environments
OSD04-C11 Development of a Portable Visible Light System for Curing Visible Light Cured Coatings for Corrosion Protection
OSD04-C12 Methodology for the Prediction of Corrosion Costs
OSD04-C13 Corrosion Inhibitor and Chemical Warfare Agent Cleaner for Military Hardware
OSD04-C14 Low Cost Corrosion/Corrosivity Sensor Systems For Ground Vehicles
OSD04-C15 Galvanic Corrosion due to Composite/Metal Direct Contact
OSD04-C16 Aluminum Cleaning Methods
OSD04-C17 Advanced Materials for Space Environment Protection of Polybenzoxazole Polymers

2. Advanced Laser Materials

The Department of Defense is interested in innovative and varied research approaches aimed at making polycrystalline materials and manufacturing technology a viable option as laser host materials. Although neodymium is a baseline dopant and lasers are the baseline application, technological interest extends to the potential for various dopants and eventually for other applications that are currently served by single crystal materials. One broad-based topic is included in this solicitation addressing these issues: OSD04-L01Polycrystalline Laser-Host Material.

Energy & Power Technology Area

Improvements in electric power will enable transformational new military capabilities. Power can be freed on ships, aircraft, and other platforms for use in advanced weapon and survivability systems, as well as significant enhancements in system flexibility. Potential life cycle and acquisition savings can be had by reduced fuel requirements, maintenance, personnel, logistics, and inventory. The Army's transformation challenge in the Future Combat System is to develop a smaller, lighter, and faster force, utilizing hybrid electric drive, electric armament and protection, and a reduced logistical footprint. The Navy's DD(X) program is counting on electric power to enable directed energy weapons, electromagnetic launchers and recovery, and new sensors, as well as supporting significant fuel, maintenance, and manning reductions. The Air Force needs electric power to replace complex mechanical, hydraulic and pneumatic subsystems, and also enable advanced electric armament systems. Improved batteries will support the individual soldier by permitting longer mission durations and reduced weight borne by the soldier. Space based operational capabilities improvements include a more electric architecture for responsive and affordable delivery of mission assets, and powering space based radar systems. Advanced electric power and a family of power components will be an essential enabler for the success of the Departments new "spiral development/evolutionary development" acquisition strategy, as spelled out in the latest acquisition documents, with an emphasis on planned upgrades, "plug and play".

Advances in batteries, chemical double layer capacitors, automotive power conditioning, electrolytics, and fuel cells are providing a technological foundation leading to major advances in electric power. Nevertheless, there exist major technical challenges to achieving the advances required in power and energy density. Among these are novel power generation concepts, batteries with a 2-3 X increase in power density and reduced weight/volume, maturation of high energy density dielectrics for capacitors, high power wide band gap devices for high temperature, high voltage operation, and advanced thermal management.

The Energy and Power Topics follow this section and are:

OSD04-EP1 Advance Cooling Designs for High Temperature Transformers and Inductors for Power Electronics
OSD04-EP2 New High Energy Density Li/Li-Ion Rechargeable/Primary and Alternative Design Munition Batteries
OSD04-EP3 Nanostructure-Enhanced Bulk Thermoelectric Materials
OSD04-EP4 Cryogenic Power Electronics
OSD04-EP5 Lightweight Power Transformer for Shipboard Electrical Power Distribution Systems
OSD04-EP6 Superconducting Developments for Compact Power and Energy Systems
OSD04-EP7 High Performance Dielectric Materials for Pulse Power Capacitor Devices
OSD04-EP8 Advanced Thermal Management Concepts Using Designer Thermo-Fluids
OSD04-EP9 Innovative Advanced Fuel Cell Manufacturing

DUSD(S&T)/Defense Health Program
Biomedical Technology Area

The Department of Defense is aggressively pursuing unified Force Health Protection strategies to protect Service members and their family members from health hazards associated with military service. Toward that end, DoD is undertaking strategies that promote healthy units and communities while improving both force morale and war fighting capabilities.

The operational force is exposed to health threats throughout the operational continuum, from CONUS fixed facilities (garrison, base, ashore) through deployment, employment, and redeployment. DoD is developing policy and procedures to assess occupational and environmental health threats for all locations. A comprehensive record of current health—and of past health events and resultant exposure levels—will be maintained for as many as 100,000 U.S. military personnel over their entire military-service cycle (the Millennium Cohort Study).

When Force Health Protection capabilities are fully implemented, commanders will have a more complete view of potential health threats. Integration of assessments from health databases and other assessments from intelligence (e.g., about land mines, directed enemy fire, fratricide) and safety (e.g., about injuries, vehicle accidents, explosives, aviation mishaps) will provide a framework for identifying future medical technology capabilities necessary for Force Health Protection.

Ensuring the health of the force encompasses several key capabilities:

- To provide FDA-approved prevention, diagnosis and treatment items for disease and injury;
- To mobilize, deploy and sustain field medical services and support for any operation requiring military services;
- To maintain and project the continuum of healthcare resources required to provide for the health of the force;
- To operate in conjunction with beneficiary healthcare; and
- To develop training systems which provide realistic rehearsal of emergency medical and surgical procedures and unit-level medical operations.

These capabilities comprise an integrated and focused approach to protect and sustain DoD's most important resource—its Service members and their families—throughout the entire length of service commitment. Three broad capability areas of particular interest are tools and techniques for risk communication, for epidemiology research, and for delivery of health education and training unique to DoD functions. These are described in more detail below:

Health Risk Assessment and Communication Decision Tools: Risk analysis is a science-based process that strives to reflect the realities of nature as accurately as possible. The Department experienced significant challenges in determining and communicating risk on illnesses among Gulf War veterans, such as that for the anthrax vaccination program, as well as other deployments. A decision support tool is needed that produces a likelihood index of risk based on epidemiological, intelligence, environmental exposure, and health information concerning deployed forces.

New Methods to Monitor Health Status: Monitoring of health status during deployments is necessary to determine etiologic factors of deployment related health change. Health monitoring should be for a sharply limited set of physiologically based indicators, and should yield an unambiguous interpretation of health status.

Force Health Distributed Learning Tools: Developing and maintaining diagnostic and treatment skills among military physicians—as well as lifesaving buddy- and self-aid skills among other military personnel and laymen—are important aspects of first-response capabilities. Advanced distributed learning and other computer-based training technology should enable all responders to assist in providing health care in emergency situations involving chemical, biological, radiological, and nuclear events as well as traumatic injury, and should assist medical professionals to maintain clinical knowledge and skills.

We have chosen the following topics in this technology area:

- OSD04-H05 Large Area Millimeter Wave Dosimetry
- OSD04-H06 Computer-Based Dynamic Patient Scheduling and Optimization of Medical Resource Allocation
- OSD04-H07 Field Optimization of Real-Time PCR for the Detection of Leishmania Parasites
- OSD04-H08 Development of a Field-Usable Diagnostic Device for the Detection of Leishmania Parasites in Sand Flies
- OSD04-H09 Rapid Determination of Complement Activation in the Battlefield
- OSD04-H10 Sensor-Based Monitoring and Intervention for Gravity-Induced Loss of Consciousness (GLOC)
- OSD04-H11 Simultaneous EEG Acquisition and Portable Near Infrared Spectroscopy for Recognition of Traumatic Brain Injury Severity and Outcome Assessments in Far-Forward Military Medical Care
- OSD04-H12 Digital Archive and Access to Lifetime Military Medical Records
- OSD04-H13 Tool for Dynamically Integrating Military and Civilian Telemedicine and Medical Informatics Systems for Homeland Security
- OSD04-H14 Develop Portable Near Infrared Technology for Detection of Pulmonary Function Following Blast Injury
- OSD04-H15 Armed Services Blood Program (ASBP), Blood Reserve Availability Surveillance System (BRASS)
- OSD04-H16 Armed Blood Services Program, Bloodborne Pathogen and Donor Deferral Early Warning System
- OSD04-H17 Development of a Hemostatic Wound Dressing Incorporating Lyophilized Platelets
- OSD04-H18 Armed Blood Services Program (ASBP), Donor Relationship Management System (DRMS)
- OSD04-H19 Next-Generation Antibiotics

All of the topic descriptions are provided on the following pages.

OSD 04.3 Topic Index

Defense Health Program Biomedical Technology Area

OSD04-H05	Large Area Millimeter Wave Dosimetry
OSD04-H06	Computer-Based Dynamic Patient Scheduling and Optimization of Medical Resource Allocation
OSD04-H07	Field Optimization of Real-Time PCR for the Detection of Leishmania Parasites
OSD04-H08	Development of a Field-usable Diagnostic Device for the Detection of Leishmania Parasites in Sand Flies
OSD04-H09	Rapid Determination of Complement Activation in the Battlefield
OSD04-H10	Sensor-Based Monitoring and Intervention for Gravity-Induced Loss of Consciousness (GLOC)
OSD04-H11	Simultaneous EEG Acquisition and Portable Near Infrared Spectroscopy for Recognition of Traumatic Brain Injury Severity and Outcome Assessments in Far-Forward Military Medical Care
OSD04-H12	Digital Archive and Access to Lifetime Military Medical Records
OSD04-H13	Tool for Dynamically Integrating Military and Civilian Telemedicine and Medical Informatics Systems for Homeland Security
OSD04-H14	Develop Portable Near Infrared Technology for Detection of Pulmonary Function Following Blast Injury
OSD04-H15	Armed Services Blood Program (ASBP), Blood Reserve Availability Surveillance System (BRASS)
OSD04-H16	Armed Blood Services Program, Bloodborne Pathogen and Donor Deferral Early Warning System
OSD04-H17	Development of a Hemostatic Wound Dressing Incorporating Lyophilized Platelets
OSD04-H18	Armed Blood Services Program (ASBP), Donor Relationship Management System (DRMS)
OSD04-H19	Next-Generation Antibiotics

OSD 04.3 Topic Descriptions

OSD04-SP1 TITLE: Attack Modeling Technology and Methodology

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop modeling techniques that accurately model an attacker and implement software tools that will allow such models to evolve and be used to evaluate software protection techniques and diagnose weaknesses in those protections.

DESCRIPTION: DoD desires to produce complex mission-critical software systems that are more affordable, predictable, and robust. Such software systems represent considerable investments of time, scientific ingenuity and Federal funding. Accordingly, software protectability has become another attribute that future DoD software systems must have. Software protection in this sense refers to protection against unauthorized execution, reverse engineering and embedded malicious code, as well as other compromises of the intellectual property and integrity of software. The DoD is presently investing in several software protection technologies with the goal of identifying a software protection methodology that will lead to software systems that are highly resistant to a variety of attacks. However, there are limited existing validated measures on the effectiveness of software protection techniques.

The Software Protection Initiative (SPI) Technology Office is interested in methods of attack modeling. Currently, software protection schemes are tested using teams of people who try to break the protection technology. This is expensive, time-consuming, and manpower intensive, and does not lead itself to a quantifiable measure of the protection scheme. If the attack methodologies can be accurately modeled and/or simulated with a degree of certainty and completeness, the strengths and weaknesses of software protection techniques could be more accurately ascertained. With this knowledge, system developers can make more informed cost/benefit decisions based on the expected strength of the attack, the cost of the system and the required protection.

Statistical representations of attackers' techniques and decision processes could be used to build comprehensive, scalable and evolvable models of attacks. One possibility is to build an attack tree that describes the approaches the attacker uses and the probability of each branching decision. Another possibility is an automated tool that will analyze a binary or source code for weaknesses and develop an attack tree or other representation that is tailored to the code structure and semantics. This data could then be used by another automated or intelligent tool that will simulate an attack against the code. The results of such a tool could be a simple pass/fail, or a more detailed diagnoses of the protection strength.

Adversaries may extend from unfunded, non-organized hackers to state funded, organized agencies. Protection technologies may include both software and hardware concepts. Examples of very basic technologies to illustrate software and hardware schemes may involve license daemons and dongles, respectively. Correspondingly, the numerical modeling should also account for the tools an adversary may use. However the attack modeling is done, the overall goal is to identify and evaluate methods for quantifying software protection strength.

PHASE I: 1) Identify, characterize and analytically evaluate current and possible future attack tools and techniques that could be used against openly documented and deployed software protection techniques

2) Propose representations for these attacks that could be the basis for automated attack generation and attack simulation tools for use against protected executables

3) Devise methods for conducting large scale experiments, collecting statistics and analyzing the significance of the results for use in both attack modeling and protection diagnoses.

4) Evaluate possible attack representations and select the most appropriate representation from the points of view of comprehensiveness, automatability and adaptability

5) Develop preliminary design and a proof-of-concept prototype to demonstrate feasibility

PHASE II: 1) Update the design and develop attack generation and simulation tools. Such tools may include specialized editors, visualizers, modelers, diagnostic tools, script generators or compilers, but must include environments to allow large-scale experimentation and data collection using the attacks represented

2) Evaluate and select the most useful set of metrics and collect enough statistics, through experimentation with the environment, to validate them
3) Demonstrate the ability to maintain, update and use large, complex attack models within the toolset and environment developed
4) Validate the results of the modeling and simulation through external red team efforts

DUAL USE COMMERCIALIZATION: A comprehensive, scalable and maintainable attack modeling toolset and experimentation environment will support a powerful new methodology to evaluate the strength and diagnose the weaknesses of various software protection techniques in both military and commercial/consumer applications. The tools, simulations and methodology will give much needed insight into software protection vulnerabilities and allow the development of more robust software protection tools and techniques.

REFERENCES: 1. Daley, K.; Larson, R.; Dawkins, J., "A structural framework for modeling multi-stage network attacks", Proceedings of International Conference on Parallel Processing Workshop, 2002
2. Lindqvist, Ulf ; Cheung, Steven; Valdez, Rico, Correlated Attack Modeling (CAM), Final Technical Report, May 2000-May 2003

KEYWORDS: Attack modeling, metrics, software protection

OSD04-SP2 TITLE: Next Generation Software Reverse Engineering Tools

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To develop new approaches and tools that can identify potential weaknesses in anti-reverse engineering techniques, when such techniques are effective enough to thwart current attack tools.

DESCRIPTION: The Software Protection Initiative (SPI) Technology Office is charged with preventing the unauthorized distribution and exploitation of critical national security software. SPI requires a strategy that balances the need for application software control and security with the need to develop, enhance, test, and validate software as it is shared with authorized end users. SPI must be able to effectively develop, leverage, and exploit software investments while still protecting software technology from unauthorized distribution or use.
One area of concern to SPI is availability of tools for software vulnerability analysis and reverse engineering. Current tools, such as SoftICE, IDA Pro, and UQBT, provide attackers with a good set of capabilities against today's commercial protection technologies. However, as future advances in protection technologies make it possible to defeat current attack tools, they are likely to present new vulnerabilities and leave some existing, but little-known vulnerabilities in place. Since protections are tested against available attack tools, developing protections against the next generation of vulnerabilities requires the next generation of tools.
SPI wishes to preview or obtain the next generation of attack tools before they reach widespread use. SPI is interested in sponsoring research into advanced tools for reverse engineering and vulnerability analysis with a focus on dynamic methods. Tools of interest include, but are not limited to, stealthy debuggers, low overhead emulators, and execution trace differencer/analyzer.

PHASE I:
1) Develop a concept for a set of the next generation of software attack tools based on current offensive and defensive Reverse Engineering technologies
2) Design and build a prototype tool that proves the feasibility of the concept
3) Perform a security penetration attack analysis using the tool and deliver summary results of tool effectiveness

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the software attack tool prototype to a complete toolset

2) Develop the prototype toolset using industry best practices
3) Perform a security penetration attack analysis using the toolset and deliver detailed results of attacks and protection effectiveness, to include attack trees, processes, times and similar data

PHASE III DUAL-USE COMMERCIALIZATION: Development of tools and technologies for the protection of high-value software against reverse engineering would be marketable in both the DoD and commercial sectors. Computer applications, either in development or fielded, where software vulnerabilities are a concern, would benefit from these technologies.

REFERENCES:
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KEYWORDS: Static Analysis, Dynamic Analysis, Debugger, Emulator, Execution Trace, Vulnerability Analysis, Reverse Engineering

OSD04-SP3 TITLE: Automated Tools for Software Protection Technology Insertion

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To develop new approaches and tools that enable software developers to ensure the security and integrity of application programs via automated means.

DESCRIPTION: The Software Protection Initiative (SPI) Technology Office is charged with preventing the unauthorized distribution and exploitation of critical national security software. SPI requires a strategy that balances the need for application software control and security with the need to develop, enhance, test, and validate software as it is shared with authorized end users. SPI must be able to effectively develop, leverage, and exploit software investments while still protecting software technology from unauthorized distribution or use.
SPI is interested in the automated insertion of protection technologies into source and/or executable application code. High-value applications require software protection that protects key intellectual property, detects tampering, and reacts to any tampering. This is referred to as "Protect/Detect/React" (PDR). Currently, advanced PDR technologies are inserted using manual or semi-automated techniques.
SPI is interested in sponsoring research into tools and techniques for automated insertion of PDR technologies, either during compilation or post compilation. Several sub-areas of interest include:
• Technology to identify the location of key Intellectual Property in the application needing protection. Intellectual Property consists of both algorithms, such as weapon design software, and data, which includes DoD derived coefficients for modeling and simulation of advanced weapon systems (Knowing the location of the IP helps determine which sections of code to protect)
• Technology to insert diversity into binary executables (e.g., a compiler that produces a large number of different variants of the same binary)

• Technology to debug and otherwise maintain and manage multiple variants of automatically protected codes
• Technology that archives and audits the protections applied to processed codes.

PHASE I:
1) Develop a concept for a set of tools that automates PDR insertion, based on current technologies. Techniques should be applicable across operating systems
2) Design and build a prototype tool that proves the feasibility of the concept
3) Perform a security penetration attack analysis using software protected by the tool and deliver summary results of tool effectiveness

PHASE II:
1) Based on the results from Phase I, refine and extend the design of the Automated PDR tool prototype to a complete toolset
2) Develop the prototype toolset using industry best practices
3) Perform security penetration attacks to analyze the protection provided and deliver detailed results of attacks and protection effectiveness, to include attack trees, processes, times and similar data

PHASE III DUAL-USE COMMERCIALIZATION: Development of tools and technologies for the protection of high-value software against reverse engineering would be marketable in both the DoD and commercial sectors. Computer applications where software vulnerabilities are a concern would benefit from these technologies.

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KEYWORDS: Binary Diversity, Compiler, Algorithm Analysis

OSD04-SP4 TITLE: <u>Polymorphic Software</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To develop new approaches and tools that enable software developers to ensure the security integrity of application programs via a diversity of executables with identical functionality, but vastly different binary signatures.

DESCRIPTION: The Software Protection Initiative (SPI) Technology Office is charged with preventing the unauthorized distribution and exploitation of critical national security software. SPI requires a strategy that balances the need for application software control and security with the need to develop, enhance, test, and validate software as it is shared with authorized end users. SPI must be able to effectively develop, leverage, and exploit software investments while still protecting software technology from unauthorized distribution or use.
One area of concern to SPI is differential analysis between two applications. The adversary may be able to use differential analysis to locate regions of interest in the executable, such as software protection

technology. This threat could be countered by injecting diversity into an application release. SPI is interested in identifying ways to inject binary diversity both at runtime and at rest.

SPI is interested in sponsoring research for two types of software protection tools: static (polymorphic) and dynamic (metamorphic) diversity generators. A polymorphic software tool, similar to polymorphic virus software, would generate unique binary applications that are functionally equivalent. Any two instances of the same application would show little, if any, similarity during differential analysis. Dynamic diversity, or metamorphic software, changes its binary signature over time. This includes both mutating to a functionally equivalent application in memory, as well as potentially rewriting its persistent binary.

The effectiveness of both static and dynamic diversity technologies can be measured in terms of various metrics: performance degradation relative to unmorphed, optimized code; susceptibility to differential analysis and reverse engineering of the protected code; and maintenance and debugging ability impacts.

PHASE I:
1) Develop a concept for a set of tools for polymorphic and/or metamorphic software creation, based on the current state of the art. Techniques should be applicable across operating systems
2) Design and build a prototype tool that proves the feasibility of the concept
3) Perform a security penetration attack analysis using software protected by the tool and deliver summary results of tool effectiveness

PHASE II:
1) Based on the results from Phase I, refine and extend the design to encompass a complete toolset
2) Develop the prototype toolset using industry best practices
3) Perform security penetration attacks to analyze the protection provided and deliver detailed results of attacks and protection effectiveness, to include attack trees, processes, times and similar data

PHASE III DUAL-USE COMMERCIALIZATION:
Development of tools and technologies for the protection of high-value software against reverse engineering would be marketable in both the DoD and commercial sectors. Computer applications where software vulnerabilities are a concern would benefit from these technologies.

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KEYWORDS: Polymorphic Software, Diversity, Static Analysis, Dynamic Analysis

OSD04-SP5 TITLE: Behavior Based Malicious Logic Monitoring and Detection

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To develop tools and techniques that insert software behavior monitoring and control mechanisms into an application to detect inappropriate behavior. When such inappropriate behavior is identified, the protection mechanisms will select from a series of responses including shut-down, interception, quarantine, and reporting.

DESCRIPTION: The Software Protection Initiative (SPI) Technology Office is charged with preventing the unauthorized distribution and exploitation of critical national security software. SPI requires a strategy that balances the need for application software control and security with the need to develop, enhance, test, and validate software as it is shared with authorized end users. SPI must be able to effectively develop, leverage, and exploit software investments while still protecting software technology from unauthorized distribution or use.

Large software development projects provide a myriad of opportunities for untrustworthy developers to insert malicious logic. Additionally, simple programming mistakes and unanticipated failure modes can provide breaches in security.

SPI is interested in the insertion of software behavior based monitoring technologies into critical applications. Research should focus on both the monitoring logic and the tool to insert that logic. The behavior monitoring system should be able to identify undesirable logic and traditional computer virus infections. The monitoring logic should also include detection mechanisms and reactive protection schemes that are woven into the application. Logic insertion is expected to be performed either on source code, or as a compilation / post-compilation step.

PHASE I:
1) Develop a concept for a set of tools for software behavior based monitoring technologies. Techniques should be applicable across operating systems
2) Design and build a prototype tool that proves the feasibility of the concept, focusing on the monitoring logic
3) Perform a security penetration attack analysis using software protected by the tool and deliver summary results of tool effectiveness

PHASE II:
1) Based on the results from Phase I, refine and extend the design of prototype tool to a complete toolset
2) Develop the prototype toolset using industry best practices
3) Perform security penetration attacks to analyze the protection provided and deliver detailed results of attacks and protection effectiveness, to include attack trees, processes, times and similar data

PHASE III DUAL-USE COMMERCIALIZATION: Development of a tool that inserts protections against "logic time bombs", "back doors", and "Easter eggs", into the application itself, as well as provides application-centric anti-virus protection, should be marketable in both the DoD and commercial sectors.

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KEYWORDS: Anti-virus, malicious logic, malware, self-checking, guards, self-monitoring

OSD04-SP6 TITLE: <u>Code Pedigree, Code Integrity, Tamperproofing, Software Protection, Software Security</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To conduct research into developing technologies that detect, locate, and expose malicious or unauthorized source code in software modules used in the development of application software.

DESCRIPTION: The Software Protection Initiative (SPI) Technology Office is charged with preventing the unauthorized distribution and exploitation of critical national security software. SPI requires a strategy that balances the need for application software control and security with the need to develop, enhance, test, and validate software as it is shared with authorized end users. SPI must be able to effectively develop, leverage, and exploit software investments while still protecting software technology from unauthorized distribution or use.

One area of concern to SPI is the changes in the software development process due to re-use of software and advanced technologies. The current trend in developing/refining software applications is to use prewritten sections or modules of code from a variety of sources to reduce cost. A specific concern is outsourced and overseas software modules. These modules pose a risk of undocumented code that could be

used for a variety of unauthorized and malicious purposes such as functional time bombs, collection of information/data and passing it on to unauthorized users, creation of back doors into networks, and the release of worms and/or viruses.
As a result, the DoD is seeking innovative research to develop tools and techniques that detect, locate, and expose malicious or unauthorized source code in software modules used in the development of DoD applications.

PHASE I: 1) Research into various techniques to detect malicious codes and identifying the strengths and weaknesses of each technique, and their breadth of applicability
2) Recommendations as to what set of tools and methodologies would locate and expose most or all types of malicious codes
3) Develop prototype(s) of one or more of the most promising tools and methodologies identified above

PHASE II: 1) Develop a "test bed" for experimentation and refinement of prototype(s)
2) Select several software "test-cases" of different programs in several different programming languages
3) Demonstrate prototype(s) using the "test bed" as a proof of concept
4) Produce full documentation of Phase II efforts

DUAL USE COMMERCIALIZATION: Development of tools and methodologies for the protection of high-value software against malicious and unauthorized code would be highly marketable in both the DoD and commercial sectors. Any computer application where software security is a concern would benefit from this technology. This technology would also be applicable to any software already in widespread use (DoD or Commercial) where protection is desired for newer versions.

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KEYWORDS: software modules, software re-use, code re-use, module re-use

OSD04-SP7 TITLE: <u>Software Pedigree Analyzer</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To conduct research into developing technologies and tools that facilitate documenting, analyzing and maintaining the pedigree of software applications.

DESCRIPTION: The Software Protection Initiative (SPI) Technology Office is charged with preventing the unauthorized distribution and exploitation of critical national security software. SPI requires a strategy that balances the need for application software control and security with the need to develop, enhance, test, and validate software as it is shared with authorized end users. SPI must be able to effectively develop, leverage, and exploit software investments while still protecting software technology from unauthorized distribution or use.
One area of concern to SPI is maintaining the pedigree of code during the development phase of the software life-cycle. Information such as who accessed certain modules, what changes were made, when and where a particular module was created, would greatly aid in maintaining the pedigree of the application and ensuring code integrity (i.e. the code performs as advertised). Such a tool would serve as a deterrent to the insider threat. While the analyzer would not detect the insertion of malicious code, or theft of a module, once discovered, the analyzer would allow one to identify the who, when and where of the illegal acts.
Characteristics of such a pedigree analyzer should include, but not be limited to the following:
- Record data on who, what, when, where, how
- Record what software analysis tools have been applied to code and results (e.g. Virus testing tool X was run , no viruses detected)
- Track usage and alert on abnormal activity

- Perform code integrity checks automatically and on-demand basis
- Present “canned” queries and accept user ad-hoc queries
- Detect, prevent and alert any tampering with the pedigree data
- Detect unauthorized copying or tampering of watermarks/fingerprints and react to such events
- Platform independent (i.e. run on Wintel, Linux, etc platforms)

As such, SPI is interested in sponsoring innovative research into developing technologies and tools that facilitate documenting, analyzing and maintaining the pedigree of software applications.

PHASE I: 1) Research into various techniques to maintain code pedigree and identifying the strengths and weaknesses of each technique.
2) Evaluate advantages/disadvantages/risks associated with new development vs leveraging current tools3) Evaluate advantages/disadvantages/risks associated with application-level vs kernel-level tools) Develop prototype(s) of one or more of the most promising tools and methodologies identified above.

PHASE II: 1) Develop a “test bed” for experimentation and refinement of prototype(s)
2) Select several software “test-cases” of different programs in several different programming languages
3) Demonstrate prototype(s) using the “test bed” as a proof of concept
4) Produce full documentation of Phase II efforts

DUAL USE COMMERCIALIZATION: Development of tools and methodologies for the protection of high-value software against the insertion of malicious and unauthorized code would be highly marketable in both the DoD and commercial sectors. Any computer application where software security is a concern would benefit from this technology. This technology would also be applicable to any software already in widespread use (DoD or Commercial) where protection is desired for newer versions.

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KEYWORDS: code pedigree, code integrity, tamperproofing, software protection, software security

OSD04-TC1 TITLE: Technology for Trusted Circuits

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors, Electronics, Battlespace, Weapons

OBJECTIVE: Develop new technologies, tools, and methodologies for circuit design, fabrication, and test/analysis that ensure the trusted nature of complex integrated circuits produced for Department of Defense (DoD) applications.

DESCRIPTION: Advanced microelectronic components such as full custom integrated circuits, application-specific integrated circuits (ASIC's), field programmable gate arrays (FPGA's), and systems-on-chip (SoC's) are critical parts of future weapons and defense systems. Such circuits are vital to the functionality and performance of modern DoD systems. In most cases, these integrated circuits (IC's) are designed by one organization and manufactured by others, then presented to the user as a packaged item. It is conceivable that additional circuitry or embedded functions might be surreptitiously added to the circuit, somewhat analogous to a software virus, backdoor, or Trojan horse. Modern fabrication technologies make it difficult to non-destructively inspect the completed IC. In general, IC users have no way to ensure and verify the trustworthiness of these IC's, that they absolutely conform to system requirements and advertised design specifications. In particular, it is difficult or impossible to non-destructively examine packaged IC's to establish complete trust that each specific IC faithfully implements only the intended design specifications, behaves predictably, and executes only intended functions. It is crucial for DoD users to establish the trustworthiness of ICs intended for use in deployed systems, so that such systems operate as intended and can not be compromised. The objective of this topic is to develop enabling design, fabrication, and test technologies to verify the correctness, reliability, and functionality of ICs after fabrication, i.e., to enable users to trust the ICs they employ. Of particular interest are cost-effective design and test techniques or tools that provide non-destructive results and offer the widest coverage of trust issues. Approaches that are based on changes to wafer fabrication should address insertion issues. The technologies and approaches developed under this topic will ensure IC's for DoD applications are trustworthy. While not of primary interest, anti-tamper technologies may be considered provided the issues of ensuring IC trustworthiness are also addressed.

PHASE I: Complete a feasibility study of the approach being offered. This study should include a complete description of the technique/tool, and an analysis of the degree of trust it brings to IC users. Provide an analysis of any performance, reliability, or other limitations or vulnerabilities that may arise as a result of the offered approach. Define metrics for IC trustworthiness and quantification approaches.

PHASE II: Develop and optimize the technologies, tools, or methodologies for ascertaining trustworthiness of IC's for defense systems. Perform critical experiments that unambiguously verify the proper operation of the technology, tool, or methodology being developed. Quantify the trustworthiness of an IC against the metrics defined in Phase 1.

PHASE III DUAL USE APPLICATIONS: Certain commercial or industrial users of IC's also demand trustworthiness in function and operation. It is anticipated that the commercial demand of the techniques developed will extend to circuit verification, reliability failure analysis, and new design tools. In the third phase of the program, a plan should be executed to make the developed techniques available to both DoD and commercial customers.

KEYWORDS: Integrated Circuits, Trusted Circuits, Circuit Design, Non Destructive Verification

OSD04-C01 TITLE: <u>In-Situ Smart Corrosion Sensors for Water Piping Systems</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop in-line, real time corrosion sensors for improved feedback to automated corrosion control systems (inhibitors) for water based utility systems.

DESCRIPTION: Water using systems are costly to operate, due to the effects of biological growth, corrosion and mineral scale. Improving the water chemistry inside these systems is the best way to overcome these problems and greatly extend the system lifetime. Implementing the optimal water chemistry today is a labor intensive and costly endeavor. The solution is to automate the process, which requires good corrosion sensors connected to an automated chemical injection system. New innovative sensors are needed for these boiler and cooling systems that can accurately measure the corrosivity of the water in real time for a variety of common water piping materials over a broad range of pH and conductivity.

PHASE I: Develop sensors and show that sensors can be used to feedback data to an automatic control system that can used in conjunction with “green” water treatment chemicals to control biological growth, corrosion and scale. “Green chemicals are environmentally friendly and reduce or eliminate the use of toxic substances used in industry standard water treatments. The product of Phase I will be a prototype corrosion sensor which will be further tested in Phase II. The developed sensor should be capable of measuring corrosion rates of steel at or below 0.01 mm/yr or less.

PHASE II: In Phase II the prototype sensor will be developed and evaluated at an Army facility. It will be installed as a component in a DoD water based utility system. Coupon racks will be installed and the coupons will be analyzed in one month intervals for six months and the results will be compared to the sensor readings. The evaluation must include a test integration as a feedback mechanism into a chemical control system.

PHASE III DUAL-USE APPLICATIONS: These sensors can be an integrated part of standardized water chemistry control systems in many places in the private sector. Medium and large scale industrial activities such as factories and universities have distributed heating and cooling networks that could benefit greatly from this technology. The sensors developed under this topic could easily find a market in the automated water chemistry control for corrosion control. As the cost of maintenance and component replacement rises, the relative cost of optimizing water chemistry in delivery networks is a much more cost effective solution. The use of these breakthrough technologies will solve heating and cooling system problems of long-term interest to the DoD and commercial sector, and can be expected to extend service life of these systems by 20%.

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KEYWORDS: corrosion, sensors, inhibitor, automation, injection

OSD04-C02 TITLE: Investigation of Electrophoresis as a Novel Coating Mechanism for Sealing Concrete

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop an electrophoretic method to lower the hydraulic permeability of concrete, as a novel form of waterproofing. Improvements to below grade waterproofing in buildings will greatly lower the general atmospheric corrosion rates of expensive equipment and materials located in basements.

DESCRIPTION: The general principle of electrophoresis has been known for some time. It has recently been demonstrated as an effective mechanism to migrate nanometer scale particles into a simple cement paste (Cardenas 2002) to lower its hydraulic permeability. This SBIR will investigate and extend this mechanism to more complex (and common) concrete composites. This technique has the potential to completely replace conventional waterproofing, which is typically expensive, contains VOC’s, and has a short effective lifespan. The Electrophoretic sealing of concrete could also be used to prevent the migration of chlorides, eliminating a primary mechanism of metallic corrosion of reinforcing bars in bridge decks and piers. It could also be used to lower the hydraulic permeability of critical containment vessels.

PHASE I: The Phase I research will entail a laboratory investigation of the electrophoritic delivery or implantation of nanometer scale particles/molecules to seal the pores of concrete. Specimens used should reflect aggregate and water to cement ratios commonly used in construction. The goal for phase I should be to lower the hydraulic permeability of cement past (water to cement ratio of approximately 0.6) from 30x10^-14 m/s to a value of approximately half or less.

PHASE II: Phase II work will field the developed technology in a below grade structure to test its effectiveness as a waterproofing technology in a real-world setting. Testing should be performed to scale up the technique from a laboratory bench size to the scale of a typical residential basement. Testing should be conducted to ensure the homogeneity of permeability reduction at the larger scale.

PHASE III DUAL-USE APPLICATIONS: This technology has the potential to overcome many of the problems associated with conventional building waterproofing. This technology has the potential to completely revolutionize the waterproofing industry for new and retrofit construction. It could also be used to lower the hydraulic permeability of critical waste containment vessels.

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KEYWORDS: electrophoresis, concrete, waterproof

OSD04-C03 TITLE: <u>Corrosion Prevention of Steel Reinforcements in Concrete in Bridge Decks and Piers, and Structures Through Electrokinetic Control of Chloride Ion Migration</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The presence of chlorides in concrete has long been known to lead to corrosion of steel reinforcing members embedded in concrete. According to Hausmann, the chloride threshold value can be expressed as the ratio of chloride to hydroxyl ion concentrations and should not exceed 0.61. In the 1970s, a technique called electrochemical chloride extraction (ECE) was developed to remove chlorides from bridge deck structures using equipment adapted from the cathodic protection industry. In this technique the steel reinforcement is used as the cathode and a distributed anode is placed on the outer surface. A positive electrical potential applied between the anode the cathode causes chloride ions to move toward the anode. The main limitation of the ECE technique is the non-uniform current distribution in the concrete due to the non-homogeneity of the reinforcing structure and the lack of complete electrical continuity of the reinforcing bars. A secondary limitation is the progressive decrease in current flow, causing a corresponding decrease in chloride extraction over the duration of the treatment.

DESCRIPTION: This SBIR will investigate a novel system for removal of chlorides which overcomes many of the limitations of the present ECE technique by applying the electrical potential across the entire deck structure. Additionally the new chloride extraction technique will use pulse reversal similar to that used in ElectroOsmotic Pulse (EOP) technology. It is postulated that this pulse reversal will greatly increase the efficiency of chloride removal by briefly depolarizing the electrodes, as occurs in EOP technology. The steel reinforcement will be incorporated into the system as a third electrode. This novel electrode geometry will be investigated for effectiveness in removal of chlorides while also monitoring the corrosion potential of reinforcing members to ensure they are protected during this process.

PHASE I: Phase I research will initiate a laboratory scale investigation into the effectiveness of an improved chloride extraction system which incorporates momentary electrical pulse reversal as well as a novel electrode geometry. The electrode orientation under investigation should include one in which the anode (positive) is at the surface, the steel reinforcing element is an optional electrode, and the cathode (negative) is on the underside of the concrete, below the reinforcing segment. Phase I will explore the effects of this system on the corrosion potential of the reinforcing elements present in the concrete to ensure their protection.

PHASE II: Phase II will evaluate this system on a small scale demonstration which could be a concrete bridge deck or pier owned by the DoD.

PHASE III DUAL-USE APPLICATIONS: Phase III would involve tailored development and application to specific military and commercial structures. If successful, this technology has tremendous potential for application worldwide. The primary market would be in the chloride removal in concrete bridge decks all around the world.

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KEYWORDS: electrokinetic, concrete, pier, bridge, chloride corrosion

OSD04-C04 TITLE: <u>Smart Self-Healing Nanotechnology Coatings</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and test multiple release, smart self-healing coatings, based on emerging nanotechnologies, capable of indicating coating damage, as well as self-repair of coating to mitigate corrosion.

DESCRIPTION: Recent advances in technology have made possible Smart self-healing coatings that can be developed by mixing microcapsules or nanocapsules into paints at the time of application. These additives enhance coating properties to make them multiple releases self-healing, corrosion resistant, or contain passive sensors (such as an indicator dye), that have the ability to alert personnel to potential coating deficiencies. Smart self-healing coatings release selected film forming and corrosion inhibiting compounds on-demand, when the coating is damaged, for example, by being cut or scratched. The film former repairs a portion of damaged areas and the corrosion inhibitors provide additional corrosion protection to the substrate underneath to prevent further degradation. Emerging nanotechnologies, that utilize nanoparticles with the ability to sense environmental conditions leading to degradation, may be used to trigger embedded coating repair systems. Once their performance envelope is established, smart self-healing coatings can be expected to significantly extend the service life of steel structures. The smart self-healing coatings could also be used for future combat systems to mitigate atmospheric as well as other forms of corrosion and ensure long-term service life for vehicles and armored personnel carriers, and artillery, etc. Other possibilities include smart self-healing coatings that would provide the proper camouflage in varying optical settings, or provide radar invisibility by using microcapsules that have radarabsorbing capabilities. These breakthrough smart self-healing coating technologies can be expected to have significant impact on solutions to problems in the DoD and industry.

PHASE I: Develop and test feasibility of multiple release smart self healing coatings for corrosion control of facilities in a laboratory environment. The range of size will include nanocapsules and microcapsules to enhance particle packing in thin dry films. The methodology will include development and testing of capsules containing film formers and corrosion inhibitors, such as nitrates, phosphates, molybdates, and silicates to inhibit corrosion of carbon steel. The microcapsules and nanocapsules will be compatible with the commonly used outdoor coatings and have a shelf life suitable for field application.

PHASE II: Develop and demonstrate multiple release smart self healing coatings for corrosion control of facilities in an operational environment. Perform development and testing of corrosion inhibiting and self healing coatings, which can be used on outdoor steel equipment, used in salt laden air found in coastal environments.

PHASE III DUAL-USE APPLICATIONS: This technology could be used in a broad range of both military and civilian applications, and represents a high payoff potential for maintenance of military vehicles and facility infrastructure such as metal buildings. Nanoencapsulation technology is emerging and has tremendous potential for developing self-repair and self-healing construction materials. There is also a good potential for commercial applications on vehicles and outdoor equipment. Basic concepts have been demonstrated, however demonstration, validation and insertion of the technology into Army use is needed.

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L. J. Bailin, “Demonstration of Multifunctional DNBM Corrosion Inhibitors in Protective Coatings for Naval Air/Weapons Systems,” Report No. NAWCADWAR-94128-60, Contract No. N62269-89-C-0258, Naval Air Warfare Center – Aircraft Division, Warminister, PA, Dec 1993.
George M. Whitesides and J. Christopher Love “The Art of Building Small," Scientific American, September 2001, p. 38.

KEYWORDS: corrosion, self-healing, coating, nanotechnology

OSD04-C05 TITLE: Concrete Admixtures that Defend Against Salt Scaling and Freeze-Thaw

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The number one problem of concrete in cold climates is deterioration caused by freezing and thawing. Deicing salts only exacerbate this problem. The objective is to define the effect of chemical admixtures on the durability of concrete and use this knowledge in the development of better admixtures.

DESCRIPTION: This SBIR will develop new admixtures to minimize the pressure buildup within fresh concrete as it freezes and on dilation of hardened concrete as it freezes. These admixtures should be developed with an understanding of correlation of chemical type, dosage, and makeup on improved freeze-thaw performance. New admixtures will provide enhanced service of concrete exposed to normal and deicer salt environments. Experience with antifreeze-admixtures indicates great potential for improvement of concrete service life at reasonable expense.
Past approaches have used changes in the air-void ratio [1] or water-cement ratio [2] to affect the structure to address freeze-thaw degradation. Salt content can cause harmful scaling at low concentrations, but resistance improves with concentration after a point [3]. Admixtures appear to create an analogous effect. These effects were apparent in working with admixtures to develop anti-freeze concrete [4,5,6,7].

PHASE I: This SBIR will investigate new concrete admixtures with the aim of reducing freeze-thaw cyclic damage. At least three novel admixtures should be tested through repeated thermal cycling. Research will be conducted to determine if admixtures affect the durability of concrete through a chemical or a physical process. The combination of admixtures identified in Phase I will be considered along with other possible admixture combinations for laboratory analysis and testing. The durability study, using freeze–thaw chambers, will evaluate the chosen chemical admixtures to define if chemical type, chemical dose, or both, affect concrete's resistance to cycles of freezing and thawing. Other measurements, such as internal stresses developed in both fresh and mature concrete during freezing, will also help to define how the admixtures affect durability. Evaluations will use mainly non-air-entrained concrete to avoid variables caused by air bubbles. Verification tests will include air-entrained samples. The goal is to find a 50% increase in durability in freeze-thaw/salt-scaling environments.

PHASE II: The most promising admixtures will be subject to a medium scale DoD test bed, located at a northern latitude.

PHASE III DUAL-USE APPLICATIONS: The commercial potential of successful admixtures is greatest for those geographic locations where freeze-thaw cycling is of primary concern. Concrete and pavements in aggressive environments in both military and commercial applications would benefit from this technology. The recently-developed antifreeze admixture technology is currently on a fast track to ASTM standardization. A similar track is expected for durability-enhancing admixtures. The benefit to state departments of transportation of even 1% improvement in service life of the nation's transportation infrastructure is estimated to be about $1.5B per year. [8]

REFERENCES:
[1] Pigeon,M.,R. Pleau, and P.C. Aitcin (1986) Freeze-thaw durability of concrete with and without silica fume in ASTM C 666 (Procedure A, Test method: Internal cracking versus scaling). Cement, Concrete, and Aggregates, 8 (2): 76–85.
[2] Okada,E., M. Hiska, Y. Kazama, and K. Hattori (1981) Freeze-thaw resistance of superplasticized concretes. Development in the Use of Superplasticers, ACI SP-68, p. 215–231.
[3] Verbeck, G.J., and P. Klieger (1957) Studies of "salt" scaling of concrete. Highway Research Board, Bulletin 150, Washington, D.C., p. 1–13.
[4] Antifreeze Admixtures for Cold Regions Concreting, CRREL Special Report 90-32 (pdf) (2 MB).
[5] Off-the-Shelf Antifreeze Admixture for Concrete ERDC/CRREL Report TR-01-2 (pdf)(544K).
[6] Off-the-Shelf Antifreeze Admixtures ERDC/CRREL Technical Report 02-7 (pdf) (1.11 MB).
[7] New Developments in Cold-Weather Concreting (pdf) (35.5KB).
[8] Civil Engineering Research Foundation (1993) High-Performance construction materials and systems. Executive Report 93-501l.E, CERF, 1015 15th St, N.W. Suite 600, Washington, D.C.

KEYWORDS: concrete, durability, freeze-thaw cycle

OSD04-C06 TITLE: Development of a Crack Resistant Durable Concrete Repair Material for Navy Concrete Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a concrete repair material that is twice as durable as current technology used by the Navy and the concrete repair industry.

DESCRIPTION: On a national level it has been recognized that the durability of repaired concrete structures is a topic of increased concern. In recent years the image of concrete has been shaken by durability problems, by often-poor performance, and most of all, by concrete repair failures.
Within the Navy, experience shows that most concrete repairs in the tidal zone, in semi-tropical marine environments, have a limited life expectancy of about 5 to 7 years.
Generally, it is the objective of the owner and contractor to strive to accomplish a repair with a life of 20 years. In practice the effective life usually falls short of this objective. For repairs associated with

expansive by-products produced by corrosion of the steel reinforcement, it is common to see new delaminations occur adjacent to patches in 1 to 3 years.
Navy concrete structures are in the state of deterioration and many of these structures, especially those in marine environments, were repaired only 3 to 7 years earlier. The Navy is facing a major challenge: How to successfully repair our facilities so as to prolong their service life. This problem is not limited to the Navy; the premature degradation of concrete structures exposed to severe environments is a multi-billon dollar problem in North America. Conservative estimates of the current cost to rehabilitate deteriorated concrete structures in United-States are in the $100 billion dollar range.
Durability of concrete repairs, to a large degree, depends on the correct choice and use of repair materials. Unfortunately, the materials we are using today do not meet the requirements for crack resistance and durability. Commercially available concrete repair materials are intrinsically crack-prone, and are generally unsatisfactory for Navy use.
Deterioration and distress of repaired concrete structures in service are a result of a combination of physical and chemical processes such as the corrosion of embedded reinforcing steel, alkali-aggregate reaction, delayed ettringite formation, etc. These processes are accelerated by the cracking of the repair materials thus allowing the ingress corrosive elements such as water, salts, carbon dioxide, sulfates and oxygen, into the concrete.
The bond of the repair material to the concrete substrate physically restrains the repair material. Although the bond is essential, it is a major factor leading to cracking and the eventual delamination and failure of the repair material. In simple terms, the repair material cracks when the tensile stress exceeds the tensile strength. While development of tensile cracks may be favorable from the point of view of stress redistribution in the concrete, the situation becomes extremely different when judged from the point of view of concrete's ability to resist the penetration of corrosive elements.
In concrete and other cement-based materials, microcracks already exist at the interfaces of the aggregate-mortar and reinforcement-mortar. When large, visible cracks become interconnected with microcracks, the network of cracks facilitates the transport of aggressive ions and gasses to the embedded reinforcement, leading to premature corrosion and deterioration.
What are needed are repair materials that are durable. Durable repairs require a two fold approach, first repair materials and strategies that address on-going corrosion adjacent to the repair and crack resistant materials. This is in conflict to what the repair industry currently markets, which are materials that are high-strength, and in most cases, high early-strength. Ironically, the material properties that contribute to high strength are counter-productive to accomplishing durability. Long-term durability is achieved by dimensional stability, which means less stress from thermal contraction, autogenous shrinkage, and drying shrinkage. The combination of factors affecting crack resistance is called "tensile strain capacity" or "extensibility". Cracking of concrete can be managed by controlling the extensibility of the material. Cement-based materials with large extensibility can be subjected to large deformations without cracking.

Development of a "Crack Resistant Durable Concrete Repair Material" must account for several important factors, including:
• Long life in marine and other severe environments
• Extensibility
• Crack resistant
• Volume stability
• Ease of placement and compaction

The SBIR Contractor shall establish guidelines for the concrete repair material, which may include factors with respect to crack resistance. For example:
Test Method: ASTMC 157 (Modified according to US Army Corps of Engineers Technical Report REMR-CS-62, 1999, p.A3)
Cracking Criteria:
Drying shrinkage: not to exceed
- at 28 days 400 millionths
- at 1 year 1,000 millionths
Test Method: AASHTO PP 34 - 99, "Standard Practice for Estimating the Cracking Tendency of Concrete."
Cracking Criteria:

Restrained shrinkage:
- No cracks within 14 days
- Implied strain at 1-year age, not to exceed
1,000 millionths

PHASE I: Identify short-term laboratory material criteria for crack resistant performance. Develop candidate concrete mixture/s. Test candidate concrete mixture/s for compliance to the crack resistant criteria selected by the SBIR contractor and Report results.
PHASE II: Identify long-term material performance criteria for application at diverse Navy locations, eg. Pearl Harbor, HI; San Diego, CA; and Norfolk, VA. Validate performance of candidate concrete mixture/s. Test candidate concrete mixture/s for compliance with crack resistant criteria at various exposures. Report results.

PHASE III DUAL-USE APPLICATIONS: Prepare MSDS, application instructions, quality assurance program for manufacture of the product proper application. Demonstrate full-scale repair at the three diverse locations. Quantify cost and life cycle savings. Small business will sell the product to the repair contractor. The concrete repair material will be used primarily in marine concrete and airfield pavements. The product will be marketed and sold to the concrete industry worldwide.

REFERENCES:
1. ICRI No. 03731 Guide for Selecting Application Methods for the Repair of Concrete Surfaces
2. ICRI No. 03733 Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces

KEYWORDS: concrete repair; corrosion; deterioration; durability; extensibility; shrinkage

OSD04-C07 TITLE: Embrittlement Fuse to Detect the Presence of Hydrogen Assisted Cracking (HAC) Effects in High Strength Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a simple monitoring system for use in the vicinity of critical high strength components that would provide an indication of the cumulative impact of conditions that can lead to Hydrogen Assisted Cracking (HAC) and premature failure.

DESCRIPTION: Hydrogen assisted cracking (HAC) of high strength materials continues to be a concern for the Navy and industry. Exposure to seawater under conditions of cathodic protection, in particular, may cause premature, catastrophic failure of a structure or component. Designs usually take the possibility of HAC into account by using metals with safely low yield strengths or limiting applied cathodic potentials. However, there may be situations in which the attempts to limit cathodic potentials are unsuccessful due to faulty equipment, operator error, design error, or unanticipated chemical conditions.
Because such situations are not planned, they might not even be recognized and recorded, leaving a component damaged to an unknown level. A conventional monitoring system of sufficient complexity to sense and report such conditions throughout the wetted volumes in a ship would be expensive, heavy, require power, and be vulnerable to damage.
This topic solicits innovative research to develop a simple monitoring system for use in the vicinity of critical high strength components that would provide an indication of the cumulative impact of conditions that can lead to HAC. The process to design a sensor would have several different directions for the development process. One possibility would be a direct detection utilizing aspects of the high-strength material in coordination with a NDT that could measure the appropriate HAC producing conditions. Another approach to the problem would be via a remote detection capability that operates independently from the material. An appropriate indicator should or some “flag” should be displayed by the device that would be readily apparent to an inspector. However, a still simple, inexpensive device producing a wireless signal indicating a failed condition would be beneficial. The detector must be sufficiently robust to survive some level of shock testing without producing a hazard. Whether high shock loading could produce

a false indication is of less importance. It is anticipated that many such devices would be placed on a ship so low cost must be a consideration.

PHASE I: Demonstration of detection and clear indication of HAC-producing conditions without false positives would be the initial requirement. Development to make the device small, robust, sailor-proof, and inexpensive should be demonstrated.

PHASE II:. Perform product form testing under controlled laboratory conditions to fully evaluate performance and capability for appropriate time periods. Evaluate sensor robustness, cost-effectiveness, failure modes and application issues. Optionally, if Navy funding is available to support an effective test, install and perform a ship trial to determine field performance and requirements for field installations. Determine optimal conditions for use, operational ranges and mitigation steps.

PHASE III DUAL USE APPLICATIONS: High-strength materials and cathodic protection are used widely in all marine systems. These sensors could be utilized in many applications.

REFERENCES: A variety of references describe conventional stress-corrosion cracking test methods, and they may provide insights for this effort. An example is Stress corrosion Cracking Test Methods by A. John Sedriks, published by NACE in 1990 as part of their Corrosion Testing Made Easy Series, B. C. Syrett, Series Editor, ISBN 0-915567-40-7. Another reference is Hydrogen Embrittlement and Stress Corrosion Cracking, published by ASM in 1984-1986, Edited by R. Gibala and R. F. Hehemann, ISBN 0-87170-185-5. While studying the literature it must be kept in mind that the stress-corrosion cracking is really a process with several steps, sometimes initially involving pit formation and sometimes resulting from hydrogen absorption. A general test method must be able to cope with stress-corrosion cracking due to anodic dissolution and stress-corrosion cracking due to hydrogen-assisted cracking. The latter, occurring in high strength metals, is more critical and should, therefore, have higher priority.

KEYWORDS: cathodic protection, high strength materials, hydrogen assisted cracking. corrosion, nondestructive testing, NDT, sensors

OSD04-C08 TITLE: <u>Sensors for the Automation of Biofouling Control</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design and build an inexpensive in situ and in-stream sensor for the measurement of total residual oxidant in natural seawater and estuarine environments, that can function unattended, capable of continuous monitoring and may supply a feedback control signal.

DESCRIPTION: Electrolytic chlorination systems are currently used on ships and submarines to control biological fouling (biofouling). These systems are installed in-line of a ships seawater system to impede the growth of biofouling. The level of chlorination in these electrolytic systems is controlled by a manual dial to set a DC current which is associated with a particular chlorination or oxidant concentration. The oxidant concentration must then be measured and adjusted manually by analyzing representative seawater samples. Monitoring of the chlorination level requires additional, periodic measurements (as much as three times a day on submarines) to ensure the proper chlorination setting. Environmental restrictions on the overboard discharge of chlorinated seawater has resulted in the development of a dechlorination system designed to reduce the chlorine level to minimal total residual oxidant (TRO) content before discharge. Presently, these restrictions apply only to dockside chlorination systems but future regulation (particularly UNDS) of shipboard systems while in port is anticipated. Furthermore, new ships designed with chlorination systems such as CVN 76, LPD 17, and DDG 51 Flight IIA are being constructed with in-line dechlorination systems as well.
Chlorination and dechlorination processes for US Navy ship seawater systems presently require manual monitoring and control. In an effort to reduce the manpower burden of regulating these systems, reduction-oxidation (Redox) probes have been considered as a viable approach for chlorination control. Redox probes are able to accurately measure the changes in redox potential between natural, chlorinated and

dechlorinated environments. Many redox devices currently exist on the open market for monitoring TRO and feedback control to disinfection and biocide treatment systems. Predominantly, these devices were designed and have been utilized in the potable water systems. However, when used in the marine environment these devices have yet to be useful from a pragmatic sense since the electrodes and membranes frequently foul and in some cases material selection do not address this harsh environment. The end result has been that these devices require frequent maintenance in order to maintain a reasonable calibration.
Performers shall conduct test & evaluation of oxidant monitoring devices to characterize there longevity and accuracy in a seawater system. In addition, the performer will perform both bench top laboratory experiments to evaluate the oxidant dose response of new electrode materials and pipe loop experiments to demonstrate longevity and utility in controlling seawater biocide treatment systems. If any of these systems proves successful, shipboard demonstrations of this device in line with a portable electrolytic chlorine generator will be conducted.

PHASE I: Develop overall sensor design and determine its relative response, resolution and accuracy to total residual oxidant levels between 0-5 ppm.

PHASE II: Develop and demonstrate an automated fouling control system, based on the designed sensor, for a shipboard environment. Conduct testing to prove feasibility over extended (minimum 1 year) operating conditions. Testing should include a control leg without fouling control. Conduct shipboard demonstration of automated biofouling control with discharge meeting state/Federal regulations

PHASE III DUAL USE APPLICATIONS: Chlorination is used widely in the commercial sector and in industrial plants. Sensors that are accurate, require minimal maintenance and are designed for seawater systems could immediately be utilized.

KEYWORDS: sensors, chlorination, seawater, biofouling, control

OSD04-C09 TITLE: <u>Model Corrosion Protection System Breakdown Utilizing Existing Data</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and validate data mining techniques to utilize existing data for development of coating breakdown models and corrosion prevention.

DESCRIPTION: Corrosion is one of the highest maintenance costs for the U.S. Navy, resulting in increased cost-of-ownership and decreased readiness. A common method of corrosion prevention involves the application of organic coatings to metal structures. Laboratory research has and is being carried out to predict the breakdown of organic coatings, and the corrosion which ensues as a result of that breakdown. There is also a large volume of operational field data available for analysis. However, this field data is in a variety of formats, was collected on a variety of structures under different corrosive environments, and for a variety of coatings systems. Such information could be invaluable to an understanding of coating breakdown and prediction of corrosion on Navy structures if it could be collected, assimilated and analyzed. The Navy seeks the development of a model utilizing data mining techniques to collect and analyze existing field and laboratory data on coating breakdown and corrosion. The proposed effort should result in a model having capabilities which may include predicting the impact (technical and cost) of current and future coatings systems in Naval operating environments, improved capabilities for accelerated coating and corrosion testing, improved life at a reduced cost-of-ownership of coatings in Naval environments, and simpler classification schemes and methodologies for corrosion type, damage, and effects. This effort would require strong collaboration with Naval facilities that have collected coating and corrosion data over many years. The model should be designed to have the facility for additional data as it is generated in the laboratory and under operational conditions.

PHASE I: Develop a framework for the model described above. Develop a methodology for collection and formatting of data across all Navy sources. Begin data collection from a small number of sources including

SNAPSHOT (COMNAVSURFLANT Tank and Void Maintenance Database), the NAVSEA Paint and Preservation Management Information System (NPPMIS), and tank coating inspection reports from the insertable stalk inspection system (ISIS), and demonstrate the feasibility of using data mining to analyze the data. Perform short-term experiments to validate the data mining methodology.

PHASE II: Based on the Phase I effort, collect and format coating system breakdown and corrosion data from Naval sources and long-term laboratory efforts. Formulate a large database and further develop the data mining algorithms. Develop and validate a prototype software package for data collection and coating system breakdown prediction.

PHASE III DUAL USE APPLICATIONS: The technology that will be produced under this effort has application in the protection of structures against environmental degradation. Managing the structural health of expensive assets is of prime concern to all government services and commercial entities, and has application to the aerospace and automotive industries.

REFERENCES:
Department of Defense, Logistics Tool Site (LogTool): http://www.logtool.net/index.html
SNAPSHOT and Other Database Overviews: http://www.logtool.net/toolextra/QuikRefs/index.html
ISIS Overview: http://www.nrl.navy.mil/content.php?P=02REVIEW110

KEYWORDS: breakdown, corrosion, data mining, protection

OSD04-C10 TITLE: Development of Corrosion Test to Predict or Rank Corrosion Performance of Current and Novel Corrosion Inhibiting Sealants, Both Conductive and Non-Conductive, in Aggressive Environments

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop experimental and prognostic tools for accelerated corrosion testing to predict the expected response and useful life of conductive and non-conductive sealants in corrosive environments.

DESCRIPTION: Currently available corrosion tests, both static (mixed metal, salt water, liquid/vapor) and dynamic (cyclic stress), have been consistently shown inadequate to differentiate between corrosion-inhibiting and standard sealants. Additionally, no corrosion test has been validated for conductive sealants that are increasing in usage for fighter aircraft. Current corrosion testing provides no information on the effect of corrosive environments on the sealant itself (polymers, fillers, etc.), changes that may affect performance, durability, and/or capability for long-term protection. In some aircraft applications, such as permanent butt gaps between various skins, corrosion-inhibiting sealants are expected to last the life of the aircraft. Corrosion tests in current specifications do not address limitations on the duration of protection provided by corrosion inhibition packages. Inhibition is usually achieved by leaching out of the inhibitors in the presence of corrosive media. Hexavalent chromium (Cr^{+6})-based inhibitors provide excellent short-term protection but do so by rapidly leaching out of the sealant resulting in poor long-term protection.
Due to increasing stringency of environmental regulations regarding hexavalent chromium, a variety of new corrosion inhibiting packages have been developed and incorporated into sealants. In order to qualify these new, environmentally "friendly" sealants, a determination of their corrosion-inhibiting potential compared to current Cr^{+6} containing sealants is necessary. Inadequate laboratory tests have delayed qualification of these materials because little distinction in performance from standard sealants has raised questions about their capabilities in real environments. Conductive sealants in development that incorporate novel fillers will also require adequate corrosion evaluation. Use of these new materials in service without adequate characterization of corrosion inhibiting properties and effects of corrosive environments on sealant chemistry and fillers may result in significant increases in either corrosion or maintenance labor to mitigate premature corrosion.

PHASE I: Develop a lab-based experimental/prognostic tool for evaluating corrosion performance that will characterize the corrosion inhibition potential, in corrosive environments, of both conductive and non-conductive sealants. Develop tool for characterizing effects of corrosive environments on current sealant chemistries.

PHASE II: Demonstrate that the tools adequately predict the expected response and useful life of corrosion-inhibiting sealants in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL USE APPLICATIONS: Corrosion inhibiting sealants are used by most military and civilian aircraft platforms. Incorporation of a laboratory test(s) to adequately predict performance and enable comparison of current and upcoming sealants would allow all users to assess benefits and risk of material changes, especially for environmentally compliant materials. Adequate and lengthy corrosion protection decreases cost for all programs.

REFERENCES:
MIL-PRF-81733 (Sealing and Coating Compound, Corrosion Inhibitive)
AMS-3265 (Sealing Compound, Polysulfide (T) Rubber, Non-Chromated, Corrosion Inhibiting for Intermittent use to 360„aF (182„aC)

KEYWORDS: accelerated life, corrosion, inhibition, sealant, testing

OSD04-C11 TITLE: <u>Development of a Portable Visible Light System for Curing Visible Light Cured Coatings for Corrosion Protection</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a safe, portable visible light curing system for field use, capable of curing visible light cured coating systems to perform touch-up repairs in a matter of seconds while pier-side or underway.

DESCRIPTION: Extensive developmental work with visible light cured coatings has been done since 1995. Under a Navy's SBIR program funded by ONR, a small business called Spectra Group Limited formulated visible light cured coatings for use as a touch-up repair coating in ballast tanks. This coating technology was demonstrated feasible as a touch up repair coating that protects against corrosion. These coatings cure in 40 to 60 seconds, emitting visible light. The visible light has strong emission above 370 nanometers (nm). Current light sources for curing visible light cured coatings are suitable for laboratory or industrial use. The design of these light sources (i.e., size, shape, weight, and surface cure area limitation) is not suitable for field use. There are two visible light cure equipment presently used to cure visible light cured coatings. These units are too heavy and cumbersome to handle in the field, and are limited to curing an area no larger than 3" x 6" in size at a time, over a 40 to 60 second period. These units, which included the light housing, power supply, and cables weighs 52 and 82 pounds, respectively. The light housing is 9" x 9" x 8.5" and 12" x 9" x 8.5" in size, respectively. The power supply is 8.25" x 9.75" x 15" and 17.5" x 10" x 27" in size, respectively. The power cord length is 6 ft. Development of a new, safe and portable visible light curing system for use in curing visible light cured coating systems in the field (e.g., bilges, confined spaces, superstructure, fasteners, pad eyes, etc.) is the goal of this effort. The new visible light curing system should be capable of providing visible light with strong emission above 370 nm to safely cure a coating in one minute or less, be compact and light weight for portability in the field (e.g., of a backpack configuration), have a longer power cord attached (i.e., 100 ft.) or be cordless, and would be capable of curing a Spectra Group's coating formulation for touch-up repairs over a wide variety of surface configurations and in hard to reach areas while on-site (dock) and at sea.

PHASE I: Design a portable light source prototype for field use that is durable, safe, and provides the necessary intensity to achieve proper cure in a matter of seconds, and capable of curing visible light cured coating systems on surfaces of various sizes and configurations (e.g., corners, edges, and hard to reach areas).

PHASE II: Conduct laboratory scale test to demonstrate required cure/performance of Spectra Group's formulations in actual application. Optimize portability of prototype design for curing visible light cured coating systems on surfaces of various sizes and configuration.

PHASE III DUAL-USE APPLICATIONS: Under program office sponsorship, the portable visible light curing system will be used in field tests on fleet vessels and hardware to demonstrate the ease and effectiveness of curing visible light cured coating systems on hard to reach areas and on minimally prepared surfaces of various sizes and configurations. Identify and begin technology transfer to commercial applications. Potential commercial applications include piers, ships, and industrial and commercial architecture.

REFERENCES:

1. L. Panico, "Pulsed UV Curing Provides User Friendly Solutions to Tough Problems", Adhesive Age, January 1977.

2. L. Panico, "Pulsed UV Curing, A Revolution in the Curing of Polymer Systems", Internal Publication (Xenon Corp.), 1998.

KEYWORDS: light source, environmentally friendly, radiation cure, touch-up repair, ultraviolet cure, visible-light cure

OSD04-C12 TITLE: Methodology for the Prediction of Corrosion Costs

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop modeling concepts to accurately determine corrosion costs in naval aircraft systems and predict cost savings from the implementation of corrosion prevention and control technologies in naval aviation.

DESCRIPTION: Corrosion of naval aircraft has been an ongoing problem that is becoming more prominent as the acquisition of new equipment is extended over a longer timeframe. Corrosion is potentially the number one cost driver in lifecycle costs. The total annual direct cost of corrosion incurred by all the military services for systems and infrastructure has recently been estimated to be as much as $20 billion. Materials, energy, labor and technical expertise that would otherwise be available for alternate uses must be allocated for corrosion control. In order to identify the magnitude and distribution of resources to be applied when designing more corrosion resistance in new Navy aircraft and spending more in corrosion research and technology, valid estimates of corrosion costs is important. While many factors make up the Navy's cost of corrosion for aircraft ownership the overwhelming one is the effort spent doing maintenance. The Navy has a data collection system that provides documentation of maintenance. The data available is comprehensive and valuable information can be gleaned including such items as; total direct maintenance manhours, manhours and items processed in preventive maintenance and manhours and items processed in corrective maintenance in the treatment of corrosion. There are, however, weaknesses in the data collection system, which understate the magnitude of corrosion maintenance. The depot level costs are not addressed. The indirect support costs, those for labor, materials and administration are not accounted for. In addition a separate estimate must be made for the corrosion prevention and treatment manhours spent on items that are repaired due to failures that are attributed to causes other than corrosion. The developed methodologies may rely on existing approaches, utilize innovative analytical modeling concepts, and/or consider knowledge-based criteria

PHASE I: Demonstrate the likelihood that a cost modeling approach can satisfy the objective of this topic and provide accurate predictions of cost savings. Develop a conceptual software model with an open architecture of adaptability and accommodation for variance in parameters.

PHASE II: Develop and demonstrate a prototype system and conduct testing to prove the feasibility of the analytical model. Apply the model to a depot facility.

PHASE III DUAL USE APPLICATIONS: The analytical model would have broad application across military commands and civilian organizations in making decisions for the implementation of improved corrosion protection systems

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1. G. H. Koch, M.P.H. Brongers, N.G. Thompson, Paul Virmani and J.H. Payer, “Corrosion Cost and Prevention Strategies in the United States”, U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-01-156, March 2002.
2. H. Mindlin, B.F. Gilp, L.S. Elliot, M. Chamberland and Ted Lynch, “Corrosion in DOD Systems: Data Collection and Analysis (Phase II)”, Metals Information Analysis Center (MIAC), Report No.8, February 1996.
3. U.S. Navy Aircraft Corrosion Prevention and Control Program, Audit Report, Report No. 97-181, Office of Inspector General, U.S. Department of Defense, June 1997.
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KEYWORDS: corrosion, cost modeling, cost savings, maintenance hours, prevention

OSD04-C13 TITLE: Corrosion Inhibitor and Chemical Warfare (CW) Agent Cleaner for Military Hardware

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a chemical system for simultaneous protection against Chemical Warfare (CW) agents and corrosion. The objective is develop a novel surface cleaner that would detoxify CW-agents impacting the military hardware surfaces and serve as corrosion inhibitors at the same time to provide corrosion protection of military weapons. .

DESCRIPTION: Many CW agents cause subtle corrosion problems that manifest into significant maintenance and repair problems with time. Protection of our military hardware (Army, Navy and Air Force) in a Chemical Warfare (CW) environment is of vital concern to the Department of Defense. In addition to the toxic contamination threat associated with the CW-agents, the simulants and the decontaminating agents that are used for destroying the surface-borne toxic CW-agents can cause severe corrosion of the material surfaces. Chemical warfare agents such as Sarin (GB), Soman (GD), VX, Mustard (HD) and Lewisite (L) can cause corrosive damage to material surfaces. Besides, the currently fielded decontaminants (i.e., decons) such as DS-2, STB and soap and water are corrosive in their interaction with certain metals like aluminum. In certain critical parts of weapon systems the effects can result in catastrophic failures. It is believed that incorporation of a multimolecular layer of selected polyfunctional organics and their chelates of polyvalent metal ions having some specific catalytic characteristic into the organic polymeric surface coatings may provide the solution.

PHASE I: Develop innovative solutions to design a conceptual model of chemical system that has the properties to decontaminate and detoxify, and inhibit corrosion of aluminum, steels and even degradation of composites. Synthesize such formulations and demonstrate the concept through laboratory experiments. Propose tasks to scale-up the synthesis and testing processes.

PHASE II: Test and demonstrate the successful corrosion inhibitor and decon formulation on actual combat weapons. Describe the restrictions and specifications. Scale up the formulation and synthesis and demonstrate its properties. Conduct testing and provide proof that the developed technology can be applied in a simulated combat scenario or on platforms.

PHASE III DUAL USE APPLICATIONS: The technology can be applied to a broad range of military hardware and even civilian applications where there is a threat under Homeland Security Department.

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KEYWORDS: chemical warfare agents, CW, cleaners, corrosion, coating, decontaminants, military weapons

OSD04-C14 TITLE: Low Cost Corrosion/Corrosivity Sensor Systems For Ground Vehicles

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design and build an inexpensive portable corrosion/corrosivity sensor system suitable for monitoring the cumulative environmental and field service exposure of individual Army tactical and support vehicles on a wide scale basis.

DESCRIPTION: A number of advancements in corrosion and corrosivity sensor systems have been made over the last two decades. Small, portable sensors exist that have the capability to wirelessly collect and transmit data [1-5]. However, these systems, designed for high asset value materiel, are still too expensive and cumbersome to deploy on a very broad basis across the numerically large fleet of Army tactical and support vehicles with low to moderate capital asset values. Ideally, the integrated sensor system to be attached to ground vehicles shall include the actual sensor device and an associated indicator/data output component. An alternate configuration could include a vehicle mounted sensor device that is permanently attached to the vehicle, and an externally located or modular indicator/data acquisition component.
The operational environment for the fleet of Army land vehicles covers a large range of thermal, humidity, and salinity conditions during its storage, transport and deployment phases of service. The thermal extremes range from sub-zero, arctic (- 40 deg F), to moderate in the temperate latitudes, to values approaching 150 deg F in equatorial (desert and jungle) regions. Thermal challenges to materiel are compounded by battlefield induced mechanical forces as well as environmental chemical corrosiveness factors such as high humidity and salinity governed by weather patterns and proximity to oceans.
The Army is seeking a durable, low cost soldier friendly technology that can easily be implemented on a wide range of assets to help identify, prevent and correct corrosion problems on its materiel. This system would also be used to monitor various corrosion prevention programs, as well as to approximate the

remaining useful service life of that particular item. Corrosion sensors detect actual corrosion of the substrate, and would help determine corrective courses of action. Corrosivity sensors, on the other hand, detect the cumulative presence and duration of aggressive environments, and will assist in the prediction of asset life, as well as provide a baseline for monitoring the effectiveness of corrosion prevention programs. Both types of sensors deployed on Army vehicles would be a valuable fleet management tool for both procurement/replacement and maintenance purposes. Sensors should be capable of being semi-permanently or permanently attached to ground vehicles for extended periods of time, such as the expected vehicle service life or the average time between major depot maintenance events. The sensor system shall not interfere with the vehicle's mission readiness in any way, and must be rugged enough to produce reliable information/data despite being exposed to the severe conditions previously described.

PHASE I: Develop overall system design and demonstrate feasibility of a corrosion/corrosivity sensor device and the associated indicator/data output component with particular attention to meeting low cost and robustness metrics for ground vehicle applications.

PHASE II: Develop and demonstrate a durable prototype system to be mounted on a ground vehicle and function in a realistic Army field service environment. Conduct testing to prove durability and reliability of both the hardware and the software over extended Army field service operating conditions.

PHASE III DUAL USE APPLICATIONS: Commercialization of the system so that it can be used in a broad range of military and civilian applications to monitor vehicle fleets in a cost effective manner.

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KEYWORDS: corrosion, corrosivity, sensors

OSD04-C15 TITLE: Galvanic Corrosion due to Composite/Metal Direct Contact

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a validated model to predict the effects of direct carbon reinforced polymer (CRP) matrix composite-metal couples.

DESCRIPTION: Modern military aircraft continue to take advantage of the material properties available through the use of CRP composite materials. Due to the increased use there are many metal composite interfaces throughout modern aircraft. The utilization of aluminum substructure in combination with CRP composites will lead to corrosion if protection schemes are reduced or subject to premature failure. Carbon fiber composites are more noble than their aluminum counterparts. The interface in the presence of a saline solution and oxygen is a potential site for galvanic corrosion. Traditionally glass isolation plies s are used between metal structures and CRP composites, however, designers have recently sought to eliminate or reduce the isolation plies. A model to predict the effect of these interfaces between different composite materials, especially imide based composites, and metal alloys needs to be developed. Of particular interest are bismaleimide (BMI) composites currently qualified for service temperatures of 3250 deg F (1788 C). Carbon reinforce BMI composites are susceptible to resin degradation when exposed to a galvanic couple resulting in resin dissolution and loss of mechanical properties. BMI materials are currently being evaluated on several DOD platforms including the F-35 Joint Strike Fighter.

The model should be integrated into a design tool with the ability to predict material corrosion and alert designers to potential problem areas. This tool will allow designers to avoid costly corrosion problems or when necessary help identify regions with increased inspection schedules.

PHASE I: Measure the effects of direct composite-metal contact using a variety of composites and metal alloys currently and proposed to be used in DoD weapon systems. Efforts will need to focus on aluminum substructure in contact with CRP composites. The effect of reducing and/or eliminating standard protection schemes will need to be addressed.

PHASE II: Develop a predictive model that can be used as a tool during of design of metal / composite structures. The model will be used for developing NDI techniques for in service corrosion evaluations.

PHASE III DUAL-USE COMMERCIALIZATION POTENTIAL: Phase III would involved tailored develoment and application within specific military or commercial aircraft programs. Commercial aircraft would benefit from the availability of this tool during the design of civilian aircraft, especially for nacelles and other warm structures.

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KEYWORDS: corrosion, aluminum, carbon reinforced polymer (CRP) composites, bismaleimides (BMIs), carbon-aluminum galvanic couples

OSD04-C16 TITLE: Aluminum Cleaning Methods

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop advanced cleaning products or regimen that result in improved corrosion resistance for aluminum alloys used on DoD aircraft.

DESCRIPTION: Proper surface preparation plays a critical role in the performance of a protective coating. Surface pretreatment usually involves degreasing and deoxidizing. Degreasing by solvent cleaning removes organic contaminants such as oil and dirt, but can leave high carbon concentrations on the surface. Solvents alone do not provide sufficient cleaning, and therefore in accordance with Technical Order (T.O.) 1-1-8, alkaline cleaners qualified to MIL-PRF-87937 are used to remove organic contaminants not fully cleaned in solvent degreasing. Because aluminum is readily attacked by alkaline solutions, the high pH solutions (pH 9-11) often contain inhibitors to minimize or prevent attack on the metal. Alkaline cleaning is followed by an acid deoxidation procedure using materials qualified to MIL-C-38334 T1 or AMS 1640B to remove the original oxide layer so that a new, contaminant free oxide layer can be formed by the application of a chemical conversion coating qualified to MIL-PRF-81706.
Surface cleaning is extremely important in that it removes common surface contaminants such as loose metal oxides, oils, dirt, etc. that have deleterious effects on the wetting and adhesion of subsequently applied coatings. However, during the cleaning process described above, matrix dealloying/redeposition of Cu often results in Cu on the aluminum alloy surface. These areas have been shown to be sites for

corrosion initiation. Advanced cleaners or regimen need to be developed that improve the corrosion resistance of aluminum alloys used in DoD aircraft such as AA 2024-T3 and AA 7075-T6.

PHASE I: Either develop a new cleaner or cleaning procedure that results in reduced copper dealloying/redeposition. Demonstrate improved corrosion resistance of aluminum alloys using corrosion screening tools including electrochemical impedance spectroscopy and potentiodynamic scanning. .

PHASE II: Validate the efficacy of the cleaner or cleaning process using simulated aircraft corrosion environments. Demonstrate compatibility of the cleaner or cleaning process with currently used and proposed DoD coating systems ensuring improved corrosion performance using the Advanced Performance Coating System Specification (AMS G8-03AA) and the corrosion tests specified in MIL-PRF-87937.

PHASE III DUAL USE COMMERCIALIZATION POTENTIAL: Phase III would involved evaluation and approval of the processes in specific military or commercial aircraft or other programs. Commercial aircraft would benefit from improved surface cleaners or cleaning procedures that result in improved corrosion resistance of aerospace aluminum alloys.

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KEYWORDS: corrosion, aluminum, cleaner, surface pretreatment

OSD04-C17 TITLE: Advanced Materials for Space Environment Protection of Polybenzoxazole Polymers

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Development of a thin coating material that can be applied to both structural and fiber polymers to protect the underlying polymer from not only atomic oxygen but also ultraviolet and vacuum ultraviolet radiation.

DESCRIPTION: Satellites operate in a very aggressive environment. Depending upon the satellite’s orbit it may exposed to visible, ultraviolet, and vacuum ultraviolet radiation, atomic oxygen, charged particles, and even micrometeorites. In order for new polymers with unique properties such as polybenzoxazoles to be utilized in this harsh environment novel coatings that protect the polymer must be developed. These coating should adhere to the polybenzoxazole polymer under cyclic mechanical loading and not add appreciable weight to polybenzoxazole fibers (<10%) while not degrading the mechanical properties of the underlying polymer.

PHASE I: Develop new protective materials that can be applied over polybenzoxazole polymers as thin coatings that will protect against ultraviolet and vacuum ultraviolet radiation and atomic oxygen. Explore coating methodologies and techniques that will allow these materials to be applied to both fibers and sheets of polymeric materials.

PHASE II: Demonstration adhesion of the coating during cyclic mechanical loading of the polybenzoxazole fiber or sheet. Demonstrate protective properties of the coating systems in a simulated space environment chamber or chambers that include a solar simulator and atomic oxygen source. Demonstrate protective coatings that significantly increase usable life of polybenzoxazole polymer in a space environment from approximately 400 hours to 10 years while not increasing the weight of fibers more than 10%. Demonstrate the presence of the coating does not degrade the mechanical properties of the underlying polymer.

PHASE III DUAL-USE APPLICATION: Demonstration of the technology on a selected space exposure experiment. The technology has potential for private sector use in new satellite and spacecraft systems.

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KEYWORDS: polybenzoxazole, atomic oxygen, space environment, protective coating

OSD04-L01 TITLE: Polycrystalline Laser-Host Material

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop materials and processes necessary to produce polycrystalline yttrium-aluminum-garnet (YAG) laser-host material 53% or greater optical-to-optical conversion efficiency. Neodymium should be considered the baseline lasing dopant but other dopants may be considered, developed, and evaluated.

DESCRIPTION: There are several programs that are currently developing High Energy Lasers (HEL) for use as weapons. Systems such as airborne laser (ABL) and the Tactical High Energy Laser (THEL) are demonstrating that recent advances in technology are making weapons systems based on lasers practical. The ABL and THEL use chemical lasers. These are large complex lasers. Their size and complexity limit their potential uses as weapons systems. Solid-state lasers have the most potential to produce relatively simple lightweight rugged lasers for use in battlefield weapons. The largest problem in scaling up solid-state lasers to HEL's is the waste heat that must be removed from the lasing material. The state of the art lasing material for solid-state lasers is single crystal Nd-YAG. This material is very expensive, can only be grown in limited sizes and simple geometries. Polycrystalline Nd-YAG would have several advantages over single crystal YAG. Due to the nature of the fabrication process it can be made in very large sizes and complex geometries. It is a lower cost process than growing single crystal YAG and should dramatically lower the cost of the lasing material. More importantly it can be made in large sizes and complex geometries. The ability to make complex geometries would allow ideas such as internal cooling channels and or cooling fins incorporated in the lasing material to be used to help remove the waste heat in the material. This should allow the production of higher power solid-state lasers.
Development of polycrystalline lasing materials has been underway for over 40 years. E Carnall first demonstrated a polycrystalline lasing material by hot-pressing CaF2 in 1966 (ref 1). R.C. Anderson first demonstrated a polycrystalline Nd-YAG in 1972 (ref 2). The optical-to-optical conversion efficiency of the polycrystalline materials has always been much lower than single crystal materials, however. Recently J. Lu and K Ueda have demonstrated that polycrystalline Nd-YAG can be produced by vacuum sintering (ref 3-7). They produced Nd-doped nano YAG powders that have a 52.7% optical-to-optical conversion efficiency and 465 mW of continuous wave output centered at 1064.2 nm. This was accomplished by carefully optimizing the starting Nd doped YAG powders and developing a sintering schedule that allowed for complete densification with no porosity and exceptionally clean grain boundaries. Any porosity, contamination at grain boundaries or second phases will drastically reduce the efficiency of the material.

PHASE I: Develop a process to produce transparent polycrystalline Nd-YAG 25 mm in diameter and 5 mm thick with in-line transmission properties close to single crystal Nd-YAG. A piece of polycrystalline Nd-YAG 25 mm in diameter 5 mm thick with an in-line transmission close to single crystal Nd-YAG will be produced and provided to the Army Research Laboratory for evaluation.

PHASE II: Demonstrate that the process can be scaled up to produce 150 mm x 150mm x 6mm polycrystals with the optical transmission closely equivalent to single crystal Nd-YAG. The polycrystalline Nd-YAG will be optimized to give at least a 53% optical-to-optical conversion efficiency and 500 mW of continuous wave output centered at 1064 nm. Other lasing dopants may be incorporated and evaluated in the YAG and other laser-host materials may be considered and evaluated, if resources permit.

PHASE III DUAL-USE APPLICATIONS: The advantages of size, shaping, and dopant concentrations beyond that amenable to single-crystal growth processes make polycrystalline laser materials highly desirable for high power and flexible lasers in both military and commercial applications. The flexibility provided through higher concentrations of lasing dopants or novel dopants would provide new commercial applications and potentially very significant cost reductions.

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KEYWORDS: laser, polycrystal, neodymium, yttrium-aluminum-garnet

OSD04-EP1 TITLE: Advance Cooling Designs for High Temperature Transformers and Inductors for Power Electronics

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: To develop new core layout and novel core designs to increase the operating temperature of inductors and transformers for power electronics applications. The increase in operating temperature of the magnetic components can greatly increase the power density of power electronics systems such as DC-to-DC and DC-to-AC converters

DESCRIPTION: The last JASONS study on DOD power and energy need as well as the most recent DOD power and energy workshop identify low loss inductors and transformers as a required technology. Programs such as the Air force More Electric Airplane (MEA) and the Navy DDX ship programs have requirements for continued and pulse conversion which requires high temperature magnetic components.
In order to meet the weight and volume requirements for FCS, MEA and the DDX ship programs, the power electronics systems need to be much smaller than the current technology. One approach to reduce the size of the power electronic system is to operate at higher temperature. Higher temperature operation reduces the size of the cooling system needed; however, the size of the magnetic components increases with temperature. Unique cooling technology is needed to reduce the size of the magnetic as the operating temperature is increased.
TACOM has been pursuing high-temperature electronics for vehicle applications, which include vehicle propulsion, active protection, electric gun, and turret control. In 1994, TARDEC completed an exhaustive design study, Electric Drive Technology Demonstrator (EDTD), for the future main battle tank and currently have three ongoing hardware demonstrator programs.
Programs such as the Air Force active denial system, the Navy electro magnetic launch and recovery system and the Army Electronic Ignition and EM armor system are some of the systems across DOD which

requires high power density systems. This SBIR can increase the power density of power conversion system for the DOD by increasing the operating temperature of magnetic components.

PHASE I: Investigate high temperature core material, new core layout. Investigate new approaches in thermal management for high power operation of transformers and inductors

PHASE II: Implement the design and construct transformers and inductors using the new material and the new cooling techniques developed in phase 1. Design and develop high temperature and high power density DC-to-DC converts which would demonstrate the magnetic components operating at temperatures up to 150 0C.

COMMERCIAL MARKET POTENTIAL: As commercial vehicles manufactures continue investigating in hybrid electric vehicles the requirements for high power density power electronics systems will increase. High temperature design of transform cores will have a very positive impact on the advancement of hybrid electric vehicles in the commercial market.

OPERATION AND SUPPORT COST (OSCR) REDUCTION: The use of high temperature core material and core cooling techniques will allow Future combat vehicles power electronic components to operate higher temperatures. The high temperature operation has far reaching logistical benefits which include the potential for reduced fuel consumption, drastically reduced production costs, reduced spare inventory and fix-forward capability (due to modularity), and less faulty repair actions (due to greater reliability).

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KEYWORDS: Transformers, Power Electronics, Core Material, Power Density

OSD04-EP2 TITLE: <u>New High Energy Density Li/Li-Ion Rechargeable/Primary and Alternative Design Munition Batteries</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Improved Li-Ion or Li battery chemistries are being sought for energy storage for electronic and small electrical equipment. New battery chemistries and designs that will provide fast activation and high power and energy in small liquid reserve configuration are being sought. Alternatives to conventional liquid reserve batteries are also being sought, as the latter are relatively expensive and provide only a small fraction of the intrinsic energy of the battery couples due to the space that must be allotted to mechanical parts, which serve to contain the electrolyte and release/distribute it under impact-spin conditions.

DESCRIPTION: Present emphasis is on achieving the highest possible gravimetric energy density. Cycle life is a secondary consideration, and can fall in the range of 100 deep cycles. Operation over the full military temperature range (-40o to 70o C) is required, with, minimal degradation and maximal charge retention. We are seeking new (including nanophase) electrode materials and new electrolytes (including polymeric electrolytes) to achieve desired improvement of 2X or greater over the present state of art. 2) Primary Lithium Batteries – A gravimetric energy density greater than 500 whr/kg at a gravimetric power density of 15 W/kg is being sought. Good storage capability is essential but operation at sub-zero temperatures may be sacrificed as a rechargeable battery could be provided for load-levelling. Of particular interest is the discovery of a highly energetic cathode reactant. New materials could include those prepared by fluorination of various forms of carbon or other materials. Atmospheric oxygen can also be considered as a cathode reactant. 3) Batteries for Smart Munitions – Munitions applications require a battery shelf life

of up to 20 years with storage and use over the full military temperature range, and must activate and perform over the full military temperature range. Suitable batteries must withstand the high acceleration, shock and spin of munitions launchers. Oxyhalide liquid reserve batteries are often used for this purpose, but present formulations and designs are difficult to produce in cylindrical battery designs less than ¼" x ¼".
Power density requirements are greater than 50 W/l. Possibilities include: a) The development of an "active" battery chemistry with a shelf life greater than 10 years. The use of relatively expensive, high purity materials is permissible. b) The development of novel activation methods. Such methods would release a highly conducting electrolyte within milliseconds after gun launch with 15,000 to 30,000. Improved activation mechanisms are also being sought for thermal batteries.

PHASE I: Phase I should result in the identification/synthesis of at least one of the major cell components for a chemistry which could provide performance exceeding the present stare-of-art.

PHASE II: Phase II will provide for further exploration of cell components and for the formulation and demonstration of a complete prototype cell or battery.

PHASE III DUAL-USE APPLICATIONS: The energy storage components under consideration here are of great potential value for use with cellular phones, laptop computers, camcorders and many other commercial electronic equipment.

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OSD04-EP3 TITLE: Nanostructure-Enhanced Bulk Thermoelectric Materials

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop and implement methodologies for new bulk thermoelectric materials that incorporate designed nanostructural and/or quantum confinement elements (superlattices, quantum dots, nanocrystals) to significantly enhance the thermoelectric figure of merit, ZT, and intrinsic efficiency. This technology development is directed at direct power generation for DoD platforms, vastly enhanced fuel efficiencies through cogeneration of electricity via waste heat utilization and auxiliary power units for DoD transport systems (ground, sea, and air), power generation and energy harvesting for remote or unattended stations and sensor systems, and solid-state cooling and refrigeration.

DESCRIPTION: Significant improvements in thermoelectric performance of semiconductor systems have recently been realized in thin films comprising nanometer scale structures, informed in part by theoretical predictions of performance enhancement by quantum confinement (1). Such enhancement has been validated by record high thermoelectric figures of merit (ZT) in n-type PbSeTe-based quantum dot superlattice systems prepared by MBE (2,3) and in p-type BiTe-SbTe and n-type BiTe-BiTeSe quantum well superlattices deposited by MOCVD (4). Recent advances in bulk thermoelectric materials have not been as dramatic; however, a recent report of compositional inhomogeneities in the cubic AgPbSbTe system that has achieved record bulk ZT values at high temperatures (5) suggests an intriguing opportunity to design bulk materials with specific nanostructural concepts (quantum dots, nanocrystals, superlattices) in mind. Such design of bulk nanostructured systems may take the form of new approaches to induce nanoscale phase segregation in the growth of bulk materials or to assembly or self-assembly of bulk nanostructured arrays. The relevant parameters to enhance the thermoelectric performance may include quantum confinement, band gap engineering to adjust the density of states and mobility of the carriers, "phonon engineering" to increase scattering by introduction of interfaces or mass fluctuations.
The development of commercially viable thermoelectric power generation systems will require major advances in low-cost growth and processing of bulk materials that incorporate nanostructural elements to enhance performance and efficiency. This program seeks to identify new approaches to accomplish these

goals. Possible approaches include dual or multi-phase core/shell semiconductor nanocrystal assemblies, rapid quench phase segregation of immiscible dual-component semiconductor composites, or high volume superlattice or van der Waals layer materials deposition that may produce monolithic units or nanopowders or lamellae that are further consolidated.

PHASE I: Identify innovative approaches with commercial feasibility to produce bulk thermoelectric materials that derive significant enhancements in thermoelectric performance through the incorporation of nanoscale elements (quantum dots, nanocrystals, superlattices, nanolamellae) within a semiconductor composite.

PHASE II: Develop and demonstrate bulk-processable nanoscale-element enhanced thermoelectric materials with ZT values in excess of 2 at 300K or 3 at 600K. Fabricate and test a prototype thermoelectric device incorporating the nanoscale-element-enhanced thermoelectric material to determine the overall system efficiency. Analyze cost and reliability issues for producing materials suitable for a commercially viable power generation system.

PHASE III: DUAL USE APPLICATIONS: The development of processable nanostructure-enhanced bulk thermoelectric materials with high ZT's will enable the development of commercially viable thermoelectric systems for power generation, waste heat recovery, and cooling.

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(4) R. Venkatasubramanian, E. Siivola, T. Colpitts and B. O'Quinn, "Thin-film thermoelectric devices with high room-temperature figures of merit", Nature 413, 597-602 (2001).
(5) M.G. Kanatzidis, K.-F. Hsu, J. Do, T.P. Hogan, F. Guo, S. Loo, "Thermoelectric Properties of Cubic AgPbnSbTe2+n", Abstract S6.3, Fall 2003 Materials Research Society Meeting, Boston, MA (Dec. 2003).

KEYWORDS: Thermoelectrics, nanostructures, nanocrystals, superlattices, quantum dots

OSD04-EP4 TITLE: Cryogenic Power Electronics

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

OBJECTIVE: Develop cryogenic power electronic materials and devices, develop and components, and optimize high-power electronic circuits and modules for cryogenic operation at or above 60 K. This technology development will enable smaller (factor of 2 to 3), lighter (factor of 3 to 5) and more efficient (factor of 5 to 10) power conversion systems for large DoD systems. Improved reliability and signature reduction are further benefits.

DESCRIPTION: Electric power has become increasingly critical for our military as it becomes more reliant on electric weapons, electrical transportation, and electronic surveillance. There has been a tremendous push within the Navy and the Air Force toward significantly more electric power on-board ships, aircrafts, and eventually satellites for propulsion, weapons systems, and sensors. As a result, there is a trend toward utilizing cryogenic technologies where size, weight, and performance are the key drivers, such as propulsion motors and power generators. The goal of this effort is to develop cryogenic power technologies that will enable significant reductions in size, weight, and losses for large power conversion systems,. This SBIR focuses on three technologies: (1) new materials or device architecture for cryogenic power electronics; (2) low AC-loss superconductor wire and components that operate at above 60 K or above; and (3) high-power electronic circuits and modules optimized for cryogenic operation. This project will address the materials, device, component, and packaging technology challenges critical to the development of significantly smaller, more efficient, lower noise, and more reliable power control and management systems.

PHASE I: (1) Perform a feasibility study to examine the potential of novel power electronic materials, components, and devices for power applications at cryogenic temperatures. Demonstrate a prototype cryogenic power circuit or module. (2) Demonstrate a superconducting wire and/or components with low AC losses at a temperature of 60 K or above and at frequencies between 60 Hz to 500 Hz. (3) Demonstrate and quantify the advantage of a cryogenic power function optimized for cryogenic operation.

PHASE II: (1) Design, fabricate, and demonstrate a cryogenic high-power module (inverter, converter, etc.). The goal is to achieve significant reduction in size, weight, and losses relative to corresponding room temperature module. (2) Design, fabricate, and demonstrate a superconducting inductor or transformer. The goal is to achieve significant reduction in size, weight, and losses relative to corresponding room temperature device. (3) Design, fabricate, and demonstrate a cryogenic power module for a specific DoD application, such as a propulsion motor controller, which includes optimized materials, components, design, and packaging . The goal is to achieve significant reduction in size, weight, and losses relative to corresponding room temperature module.

PHASE III DUAL USE APPLICATIONS: The technology development under this SBIR can be used in power conversion equipment for commercial cruise ships and in larger electrical utility systems.

KEYWORDS: Power Electronics; Cryogenics; Superconducting Motors and Generators; Power Density; Power Devices; Power Circuits; HTS Superconducting Wire; YBCO.

OSD04-EP5 TITLE: Lightweight Power Transformer for Shipboard Electrical Power Distribution Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: DD (X); CVN (X)

OBJECTIVE: Develop lightweight voltage step-down equipment to be used in an electric vehicle (air, ground or marine) power distribution system.

DESCRIPTION: Given high power load requirements to include propulsion, auxiliary, and weapon, associated with future mission requirements , compact, lightweight and efficient power conversion hardware will be needed for stepping low to medium voltage (450 VAC up to 13.8 kV) power down to lower voltages. Conventional 60 Hz transformers are too large and heavy. One concept being considered involves use of power electronics to convert the 60 Hz waveform to a high frequency (above 5 kHZ), use of a small high frequency transformer to step down the voltage, and additional power electronics to convert the power back to 60 Hz at the desired lower voltage. Other technical approaches will be considered. Reductions in both weight and volume of at least two fold are desired. Additional benefits such as voltage regulation and power factor correction are also of interest. Advanced cooling techniques, emerging material developments, and advanced solid state switching are anticipated to make this concept feasible. Only proposals that are innovative, address R&D, and involve technical risk resulting in high pay-offs will be considered.

PHASE I: Define an approach that will provide clean electrical power necessary for low to medium voltage distribution systems having an input and output frequency requirement of 60 Hz. This assessment will include in-house generated experimental data, literature search results, and or appropriate analytical modeling. Provide design calculations as well as preliminary cost analysis.

PHASE II: Fabricate and demonstrate a reduced scale prototype transformer based on concepts and technologies defined in phase 1. Attributes to be assessed include weight, volume, and harmonic content of output waveform. Targeting specific Defense Acquisition Programs, prepare an insertion strategy for test at a Engineering Development Model (EDM) or test facility and or Land-Based Test Site (LBTS.) Prepare a business plan and commercialization strategy. All costs for DoD facilities and personnel will be paid directly by the DoD and will not be funded through the small businesses SBIR funding.

PHASE III DUAL USE APPLICATIONS: Using the lessons learned from Phase II, refine the prototype design and fabricate the full scale development model to be used in conjunction with the targeted Major Defense Acquistion Program and implement in an EDM or the LBTS.

PRIVATE SECTOR USE OF TECHNOLOGY: Industries that will benefit from this technology are the maritime and power grid industries. Other industries to benefit are the transportation industries that will be able to utilize smaller, lighter power transformers in their all-electric products.

REFERENCES:
1. MIL-STD-1399 (NAVY), "Interface Standard For Shipboard Systems, Section 300a Electric Power, Alternating Current.
2. MIL-STD-461E, "Requirements For the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment."
3. MIL-S-901D "Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment
4. MIL-STD-810-F, "Department of Defense Test Method Standard For Environmental Engineering Considerations And Laboratory Tests

KEYWORDS: Power Transformer; Solid State; Medium Voltage; Thermal Management; Shipboard Electric Plant.

OSD04-EP6 TITLE: Superconducting Developments for Compact Power and Energy Systems

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Develop advanced high-temperature superconducting (HTS) wire and/or coil technology for use in compact and lightweight superconducting power components (generators, motors, transformers, etc.) that deliver megawatts of power for directed energy weapons, electric ship drive, and other applications.

DESCRIPTION: The military services (Air Force, Navy, and Army) are currently pursuing the development of HTS generators, motors, power conversion technology, SMES, etc. that provide compact, high power systems which have reduced cooling requirements for operation. Low temperature superconductors (LTS) entail heavy refrigeration load requirements. Newer HTS BiSrCaCuO superconductors operate at 20 – 35 K for these applications, but may not be ideal in certain situations for superconducting magnet and field windings due to operating temperature or ac losses in the pure silver matrix. As an example, high power microwave applications require a millimeter wave source tube enabled by superconducting magnets. Using LTS wire requires the source magnets to be cooled to 4 K by a two-stage cryogenic refrigerator which compressor may not fully function in battlefield conditions and consumes kWs of electrical energy. The introduction of YBaCuO-coated conductors allows operating temperatures up to 60 – 77 K, greatly reducing the cryogenic cooling requirements. With availability of the YBCO coated conductor becoming inevitable, keeping operating temperatures closer to 77 K with high-current, in-field capability in combination with appropriate stabilization layers and ac loss considerations that maintains effective engineering current densities in the HTS wire is desired for military applications. Additionally, magnetic coil designs using YBaCuO must be developed by determining the performance characteristics and limits on mechanical and electrical properties through testing as well as associated quench protection issues for these windings.
Efforts may be focused on either HTS magnetic windings, HTS conductor enhancements or both. Use of YBCO coated conductor is preferred, but BSCCO and MgB2 wire is acceptable; LTS wire is not acceptable.

PHASE I: Identify approaches and determine the best method for HTS magnet/coil windings or HTS enhancements, especially effective pinning centers, low ac loss structure, and appropriate stabilization layers. Identify issues and address any opportunities or potential problems. All concepts should be scaleable.

PHASE II: Fabricate a prototypical device or hardware demonstration of the chosen magnet/coil winding design or lengths of the HTS conductor verifying the effectiveness of the architecture. Models and/or simulations, validated by demonstrations and which capture the relevant engineering issues are desirable. Testing should consider issues such as quench protection measures; mechanical, electrical, and thermal properties of the HTS tape; and performance at the operating temperature and applied current density.

PHASE III DUAL USE APPLICATIONS: Military applications will include compact, lightweight generators, motors, gyrotron magnets, inductors and transformers for high-power applications such as directed energy weapons, electric ship drive, or energy storage devices. Commercial applications include power transmission cables, transformers, generators, and motors for the power utility industry.

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1. Part II: Large Scale, IEEE Transactions on Applied Superconductivity, Vol. 11, 1447-2635 (March 2001).
2. C.B. Cobb, P.N. Barnes, T.J. Haugan, J. Tolliver, E. Lee, M. Sumption, E. Collings, and C.E. Oberly, “Hysteresis loss reduction in striated YBCO,” Physica C, 382, 52 (2002).
3. T.J. Haugan, P.N. Barnes, I. Maartense, E.J. Lee, M. Sumption, and C.B. Cobb, “Island growth of Y2BaCuO5 nanoparticles in (211~1.5nm/123~10nm)xN composite multilayer structures to enhance flux pinning of YBa2Cu3O7-d films,” J. Mater. Res., 18, 2618 (2003).
4. T.J. Haugan, M.E. Fowler, J.C. Tolliver, P.N. Barnes, W. Wong Ng, and L.P. Cook, “Flux Pinning and Properties of Solid Solution (Y,Nd)1+xBa2 xCu3O7 d Superconductors,” Ceramic Trans., 140, 299 (2003).
5. Y. Iwasa, H. Lee, J. Fang, and B. Haid, “Quench and Recovery of YBCO Tape Experimental and Simulation Results,” IEEE Trans. Appl. Supercond., 13, 1772 (2003).

KEYWORDS: HTS coated conductor, superconductivity, YBCO, HTS magnets, quench, flux pinning, conductor stabilization, ac loss

OSD04-EP7 TITLE: High Performance Dielectric Materials for Pulse Power Capacitor Devices

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Develop state-of-the-art, high performance, polymer-like thin films through a vacuum deposition vapor phase process.

DESCRIPTION: Compact, high energy density, pulse power capacitors will be the enabling technology for all future weapon systems the DoD plans to pursue. These capacitors will be used in pulse forming networks (PFNs) for the conversion of prime electrical energy into short pulses needed to energize loads such as directed energy and kinetic energy weapons and high power microwaves. Therefore, research objectives include a strong emphasis on thin, flexible dielectrics with an extremely high voltage breakdown strength (> 20KV/mil), a dielectric constant greater than 2, and low loss (0.1%). In order to achieve these gains in electrical properties, the electron traps commonly found in traditional polymers (i.e. from residual catalysts, impurities, solvents, stabilizers, antioxidants) must be greatly reduced. Preparation of a continuous dielectric film by a vacuum deposition vapor phase process would be beneficial in reducing electron traps and hence, improving the voltage breakdown strength of the material. These deposition processes may include, but are not limited to one of the following: low-defect density ion beam deposition, pulsed laser deposition, plasma-ion-assisted deposition, etc. Proposal may also include superior developments or improvements to impregnants, foils, conductors and/or advanced packaging concepts that will enable leading-edge, pulse power, high energy density (>5 J/g) capacitor capabilities with nanosecond delivery rates (burst mode). Attention to thermal management issues within the capacitor device are also critical due to a need for increased shot life, increased pulse repetition rates, and high voltage reversal tolerance. The proposed research should provide a substantial reduction in size, weight and volume of the capacitor component over state-of-the art devices while delivering superior electrical and thermal performance.

PHASE I: Demonstrate novel, polymer-like dielectric materials fabricated through vacuum deposition vapor phase processes with substantial improvement in the voltage breakdown strength, and dissipation factor over the current state of the art. Small prototype laboratory capacitors should be fabricated and tested to demonstrate the feasibility of the technology.

PHASE II: Demonstrate development of larger rolled capacitor components using innovative, polymer-like dielectric materials developed through a continuous (reel to reel) vacuum deposition vapor phase process. Actual application testing should be performed and electrical, thermal and life assessments made.

DUAL USE COMMERCIALIZATION: Military unique materials/capacitors will provide excellent margins for the high-end commercial sector. Potential applications include portable pulsed power systems, electric utilities, aircraft engine ignition systems, and deep oil/well drilling.

REFERENCES: 1. F.F. Shi, “Recent Advances in Polymer Thin Films Prepared by Plasma Polymerization: Synthesis, Structural Characterization, Properties, and Applications,” Surface and Coatings Technology, Vol. 82, No. 1, July 1996.
2. M. Ashida, Y. Ueda, T. Watanabe, “Epitaxial Growth of Low Molecular Weight Polypropylene from Vapor Phase” Journal of Polymer Science: Polymer Physics Edition, Vol. 16, 179-188, 1978.
3. M. Rabuffi, G. Picci, “Status Quo and Future Prospects for Metallized Polypropylene Energy Storage Capacitors”, IEEE Transactions on Plasma Science, Vol. 30, No. 5, October 2002.
4. M. Hudis, “Technology Evolution in Metallized Polymeric Film Capacitors Over the Past 10 Years,” in Proc. 16th Capacitor Resistor Technology Symp, New Orleans, LA, Mar. 11-15, 1996, pp. 200-208.
5. J. Chang, Y-S Lin, “Dielectric Property and Conduction Mechanism of Ultra-thin Zirconium Oxide Films”, Applied Physics Letters, Vol. 79, No. 22, November 2001.

KEYWORDS: Dielectrics, low-defect density ion beam deposition, pulsed laser deposition, plasma-ion-assisted deposition, capacitors, impregnants, pulse forming networks, Marx bank, power electronics

OSD04-EP8 TITLE: Advanced Thermal Management Concepts Using Designer Thermo-Fluids

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Develop robust advanced thermal management concepts utilizing designer thermo-fluids to dissipate high heat fluxes and transport high heat loads for electric weapon platforms.

DESCRIPTION: Proposed electric weapon concepts will result in heat sources that will potentially consist of both large and small areas operating at high heat fluxes in excess of 500-1000 Watt/cm² and require the transport and rejection capability greater than 100kW of heat. These electric weapon concepts are typical of Directed Energy (DE) concepts, e.g. high power laser and high power microwave systems, with associated power conditioning electronics for prime power generation. The thermal management of the DE weapon and associated power electronics is critical and is further complicated by the limited capability and availability of current thermo-fluids. Thermo-fluids, in this context, are those fluids with specific thermodynamic properties that enable thermodynamic processes to occur. These thermodynamic processes can then be used to enhance the transfer of heat and allow for, or enable efficient thermal management processes. However, these fluids are limited in use by the same thermodynamic properties that allow either the thermodynamic or thermal management processes to occur. For example, water is considered to be one of the best candidates for a wide range of thermal management applications due to the high latent heat of vaporization. However, the freezing temperature limits the use of water in realistic applications for the military. In addition, there is no thermo-fluid that is viable for temperature ranges of 300-400^oC without encumbering a large temperature drop between the device and thermo-fluid loop. “Nano-fluids” have been investigated and may allow for the capability to “design” fluids for specific applications by tailoring bulk fluid properties using nano-scale particulate structures. For this topic, the addition of nano-scale particulates in a thermo-fluid, in and of itself, is not considered sufficient to address the full potential for a designer thermo-fluid. However, if there are molecular interactions between the thermal fluid molecules and the particulate surface, for example due to the particulate surface morphology and or polar nature of the fluid molecules, there may be a shift in the thermodynamic properties of the bulk thermal fluid. This shift in thermodynamic properties may allow for the manipulation of thermal fluid properties that may enhanceme and optimize thermal management processes for specific applications. Furthermore, if the addition of heat to the nano-fluid results in additional molecular reactions between the fluid and the particulate structures, there exists the potential for added thermal energy storage or energy harvesting through chemical reactions.

PHASE I: Determine the feasibility (e.g. concept analysis and subscale experiment) of the proposed cooling concept, address integration issues, and provide sufficient analysis to demonstrate system level payoffs.

PHASE II: Develop, demonstrate, and validate the proposed cooling concept to show integration viability into a weapon platform.

DUAL USE COMMERCIALIZATION: Potential military applications include cooling power conditioning electronics and directed energy weapons. Potential commercial applications include cooling power conditioning electronics and commercial high power microwave devices.

REFERENCES: 1. Das, S.K., Putra, N., Roetzel, W., “Pool Boiling Characteristics of Nano-Fluids,” International Journal of Heat and Mass Transfer, Vol. 46, pp. 851-862 (2003).
2. S. Lee, S. U. S. Choi, S. Li, J. A. Eastman, “Measuring Thermal Conductivity of Fluids Containing Oxide Nanoparticless”, ASME, J. Heat Transfer, V. 121, p. 280 (1999).MER Corporation, Topic Number N03-054
3. J. A. Eastman, S. U. S. Choi, S. Li, W. Yu, L. J. Thompson, “Anamalously Increased Effective Thermal Conductivities of Ethylene Glycol-Based NanoFluids Containing Copper Nanoparticless”, Applied Physics Letters, V.78, No.6, p. 718, (2001).
4. X. Wang, X. Xu, and S. U. S. Choi, “Thermal conductivity of Nanoparticles-Fluid Mixture”, Thermophysics and Heat Transfer, V. 13, No. 4 p. 474 (1999).
5. S. U. S. Choi, “Enhancing Thermal Conductivity of Fluids with Nanoparticless”, Developments and Applications of Non-Newtonian Flows, ASME, p. 99 (1995).
6. Y. Xuan and Q. Li, “Heat Transfer Enhancement of Nanofluids”, Inter. J. Heat and Fluid Low, 21 58 (2000).
7. R. L. Hamilton and O. K. Crosser, “Thermal Conductivity of Heterogeneous Two-component Systems”, I & EC fundamentals, 1, 187 (1962).
8. Z Hashin and S. Shtrikman, “ A Variational Approach to the Theory of the Effective Magnetic Permeability of Multiphase Materials”, J. Appl. Phys., 33, 3125 (1962).

KEYWORDS: power conditioning electronics, high power microwave, laser diode, directed energy, two phase cooling, boiling, high heat flux, thermal management, harsh environment

OSD04-EP9 TITLE: <u>Innovative Advanced Fuel Cell Manufacturing</u>

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

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Investigate and develop next-generation fuel cell technologies for high altitude airships and long endurance high altitude (LEHA) UAVs.

DESCRIPTION: Improved lightweight electrochemical energy production and storage devices will be needed to provide/supplement the primary power systems on systems such as high altitude airships and long endurance high altitude (LEHA) surveillance aircraft. For high altitude airship applications, fuel cell technologies must be regenerative/rechargeable and operate continuously at 70,000 feet for one year or more. For LEHA aircraft, fuel cells are needed for auxiliary power and/or prime power for increased efficiencies and longer endurance. Components must accommodate high current draw and have the potential to operate as a system requiring no maintenance. New technologies and improvements to existing technologies (e.g. life-expanding or performance-enhancing technologies for existing designs) will be considered.
Examples of desirable performance characteristics include the generation of 600-900 kW-hrs for 16 hours for high altitude airship applications and approximately 50 to 100 kilowatts for LEHA aircraft applications.

PHASE I: Conduct feasibility studies, technical analysis and simulation, manufacturing and production analysis, or small-scale proof-of-concept studies, according to proposed innovations and improvements. Throughput, life-cycle response, temperature response, and other performance properties should be considered and measured, where applicable. Fuel cell short stack demonstration tests are required.

PHASE II: Implement technology assessed in Phase I effort. Phase II effort should include demonstration of power storage capabilities, combination of components to provide additional power, and integration with power systems with high current draw and cycling characteristics similar to those required to sustain a HAA/LEHA aircraft. Full testing and verification of performance properties is required.

PHASE III: The contractor shall finalize the advanced fuel cell technology, demonstrate the technology in full-scale HAA/LEHA aircraft, and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would advance fuel cell technologies in both the government and private sectors for ground/air electric vehicles.

REFERENECES:
(1) http://www.acq.osd.mil/bmdo/barbb/haaactd.htm
(2) Khoury, GA and JD Gillett, Airship Technology, Cambridge University Press, New York, 2002.
(3) "Development of Vehicle Subsystems," Review of the Research Program of the Partnership for a New Generation of Vehicles: Sixth Report, National Academies Press, Washington, DC, 2000.

KEYWORDS: energy storage, renewable energy, fuel cell stack, rechargeable battery, regenerable power, high altitude airship

OSD04-H05 TITLE: Large Area Millimeter Wave Dosimetry

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop a millimeter wave dosimetry system that will provide a real-time or near real-time time resolved and calibrated measure of beam energy area density. The area covered should be approximately 3 m by 3 m. Difficulties in the measurement of millimeter wave radiation power density hampers determination of permissible exposure limits for personnel by health and safety professionals. Reflections of millimeter waves from objects in the environment are a source of significant uncertainty in assessment of safety in exposure situations. Thus, it is difficult for health physicists to ascertain compliance with DODI 6055.11 with respect to millimeter waves.

DESCRIPTION: Current dosimetry tools rely on detectors that integrate the received millimeter power over approximately 1 cm2, and only give the power for that part of the beam intercepted by the detector. Additionally, information as to which portion of the beam being intercepted is not easily obtained by these techniques. As a result of these inadequacies, accurate power measurements of millimeter wave beams are practically impossible. Development of new applications of millimeter wave technology is being hampered by this lack of precision. Needed is a measurement system to assess power over a much larger of area than is now possible. Such a system should be able to obtain such measurements in real or near real-time.

PHASE I: Examine current techniques for measurement of millimeter wave power density and determine possible alternatives. Select a candidate technology or develop a new concept. Design a prototype system.

PHASE II: Build a prototype system and demonstrate the capabilities to fulfill the stated need to be able to measure power over an area of approximately 9 m2.

PHASE III: Build and demonstrate a system capable of performing real or near real time measurements in a field environment.

REFERENCE: Durney, C.H., Massoudi H., and Iskander, M.F. Radiofrequency Radiation Dosimetry Handbook (Fourth Edition), U.S. Air Force School of Aerospace Medicine Technical Report USAFSAM-TR-85-73, Brooks Air Force Base, TX, 1986.
KEYWORDS: millimeter waves, dosimetry

OSD04-H06 TITLE: Computer-Based Dynamic Patient Scheduling and Optimization of Medical Resource Allocation

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DOD(HA) PEO IM/IT

OBJECTIVES: To investigate artificial intelligence and operations research techniques for application to dynamic computer-based patient (including outpatient) enterprise wide scheduling and optimization of allocations of health care provider personnel, medical equipment, and facilities resources under an Enterprise Resource Planning (ERP) system for complex medical situations. The goal is to effectively manage and prioritize patient access to healthcare in order to minimize time and distance impact on patients and to optimize the allocation of military health care personnel, equipment and facilities resources.

DESCRIPTION: Proposals submitted against this topic, should present innovative approaches to examine military health system medical appointment scheduling and health resource allocation practices, design alternatives, identify design tradeoffs, and validate proposed designs with specifications and/or executable prototypes. It is very frustrating for patients within the military health system to make multiple trips to the same health care facility on multiple days, or to repetitively walk from one end of the facility to other to complete poorly arranged appointments. Likewise poorly coordinated allocation of provider personnel, equipment and facilities can significantly detract from the effectiveness and efficiency of the military health system. Dynamic enterprise-wide scheduling is the ability to arrange or schedule a service or a set of services for eligible Military Health System (MHS) beneficiaries at any time. In order to simultaneously support reception of combat casualties, air evacuations from overseas, mass casualty situations as well as routine cases, the military health system needs a dynamic priority-based needs scheduler. Enterprise-wide medical and dental scheduling is also part of “One Stop Shopping” customer services and ensures that the beneficiary can make one stop to fulfill multiple clinic scheduling requirements (e.g. standardized appointment types) and obtain information prior to receiving the health care service(s). An ideal system concept would facilitate patients scheduling their own sets of appointments and services via “intelligent” telephone and/or web browser based access. When the beneficiary arrives for service, enterprise-wide scheduling should already have collected prerequisite information, so verification can occur with the beneficiary and services that can be rendered. Enterprise Resource Planning is important to insure optimum use of system resources.

PHASE I: should determine the feasibility of developing a dynamic enterprise-wide scheduling solution for the military health system. The researcher will develop the methodology, computational approaches and architectural concepts to support design and implementation of the dynamic enterprise-wide scheduling system. Problem formulation should take into account heterogeneity and voluminous nature of distributed military health care data sources. Phase I will also identify specific software development, design tools and provide preliminary concept definition.

PHASE II: should continue to present innovative approaches to examine military health system medical appointment scheduling and health resource allocation practices, design alternatives, identify design tradeoffs, and validate proposed designs with specifications and/or executable prototypes. The contractor would construct a prototype system test bed and enlarge the range of existing scenarios of patient encounter validation cases in order to demonstrate how information technology can be used to effect dynamic scheduling and resource allocation within the entire military continuum of care.

PHASE III DUAL USE COMMERCIALIZATION: This SBIR has strong commercialization potential. Phase III should provide an information technology solution to Department of Defense, Department of Veterans Affairs and commercial healthcare activities. This technology may potentially benefit NATO countries as they move to modernize their healthcare delivery systems.
Candidate technologies designed and demonstrated under this SBIR project should be readily applicable to provision of health care within civilian settings with extensive continuum of care business practices that resemble those of the military; these would include those enterprises such as HMOs that encompass a full range of services from outpatient primary care in remote clinics to intensive care within large teaching medical centers.

REFERENCES:
1. Ella M. Atkins, Tarek F. Abdelzaher, Kang G. Shin, and Edmund H. Durfee.
Planning and resource allocation for hard real-time, fault-tolerant plan execution.
In Oren Etzioni, Jörg P. Müller, and Jeffrey M. Bradshaw, editors, Proceedings of the Third International Conference on Autonomous Agents (Agents'99), pages 244-251, Seattle, WA, USA, 1999. ACM Press. Available at <URL: http://ai.eecs.umich.edu/people/marbles/gatech/agents99.ps>
2. Michel Aubé and Alain Senteni.
A foundation for commitments as resource management in multi-agent systems.
In Tim Finin and James Mayfield, editors, Proceedings of the CIKM '95 Workshop on Intelligent Information Agents, Baltimore, Maryland, 1995. Available at: <URL:http://www.cs.umbc.edu/~cikm/iia/submitted/viewing/aube.ps>

KEYWORDS: Medical Informatics, military, Healthcare, CPR, Computerized Patient Record, enterprise, scheduling, ERP

OSD04-H07 TITLE: Field Optimization of Real-Time PCR for the Detection of Leishmania Parasites

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: There are two main objectives to this proposal. First, take four separate RT-PCR leishmaniasis assays (a Leishmania-generic assay as well as assays specific for L. major, L. tropica, and visceral leishmaniasis) that are currently under development at the Walter Reed Army Institute of Research (WRAIR) and combine them into a single assay able to detect and differentiate the different types of leishmaniasis present in the Middle East. Second, use state-of-the-art technology to produce field-stable reagents for this assay that do not require refrigeration or freezing, thereby allowing for the use of this assay in far-forward locations such as Iraq.

REQUIREMENT: Develop a single RT-PCR assay that can be used in a field environment to quickly and accurately detect and differentiate the primary species of Leishmania found in the Middle East. Development of this assay is an extremely high priority to the DoD due to 1) the large number (currently >400) of leishmaniasis cases in soldiers deployed to Iraq, 2) the fact that many soldiers are being needlessly evacuated from Iraq to the United States due to inaccurate diagnosis, and 3) the fact that the course of treatment for leishmaniasis is dependent on the species of parasite and current methods do not provide this information in a timely manner.

DESIRED CAPABILITY/CONCEPT OF THE FINAL PRODUCT: We envision a rapid detection assay capable of determining if a clinically ill patient has leishmaniasis, and, if so, what species of parasite (L. major, L. tropica or L. infantum/donovoni/chagasi) is causing the infection. The developed assay will be able to be used in an austere operational environment in which maintenance of a reliable cold-chain will be problematic. The assay must be developed for the RAPID, Smartcycler or Lightcycler RT-PCR platforms, with priority given to assays developed for the RAPID platform. The RAPID was recently selected by the Joint Biological Agent Identification and Diagnosis System (JBAIDS) program as the standard DoD deployable RT-PCR platform. The assay should provide >90% sensitivity and >90% specificity when compared to cell culture and/or microscopy.

DESCRIPTION: The ability to quickly identify infectious agents capable of causing disease in military troops is a major component of the Military Infectious Disease Research Program (MIDRP). The leishmaniases are a diverse group of diseases caused by protozoan parasites of the genus Leishmania and transmitted by phlebotomine sand flies. An estimated 12 million people suffer from leishmaniasis with more than a million new cases reported annually. The leishmaniases include a wide spectrum of diseases ranging from the self-healing cutaneous form to a potentially fatal visceral disease. To date, over 400 confirmed cases of leishmaniasis have occurred in US soldiers deployed to Iraq. Each infected soldier must be evacuated to the Walter Reed Army Medical Center where they received up to 20 days of intravenous drug therapy (Pentostam). It is anticipated that during 2003/2004 over 1,000 cases of leishmaniasis will occur in soldiers deployed to Operation Iraqi Freedom (LTC Peter Weina, Director, WRAIR Leishmania Diagnostic Laboratory, personal communication).

There are currently no standardized, field-deployable assays that can be used for the detection and identification of leishmaniasis in an operational setting. The 520th TAML used a RT-PCR assay for the diagnosis of leishmaniasis in Iraq; however, maintenance of a cold-chain for the storage of reagents was problematic. As currently configured this assay is not appropriate for use in the Army's Combat Support Hospitals. A field-deployable RT-PCR that can detect and differentiate the different species of Leishmania is urgently needed for several reasons:

1) A large number of military personnel are being needlessly evacuated from Iraq due to clinical symptoms that might result from a Leishmania-infection. Unfortunately, many of these soldiers are in fact NOT infected with leishmaniasis, but have symptoms due to some other problem (i.e., severe sand fly bites or other dermatological conditions). The ability to provide an accurate field diagnosis would limit the number of patients who are unnecessarily evacuated.

2) The species of Leishmania infecting a soldier determines the exact treatment that will be provided. For example, soldiers infected with L. major are receiving 10 days of treatment with IV Pentostam, whereas soldiers infected with L. tropica would normally receive 20 days of treatment (LTC Glenn Wortmann, personal communication). Iso-enzyme analysis, the current method of identifying the species of Leishmania, is labor intensive and requires up to 2-weeks before a species determination can be made. A RT-PCR assay that could rapidly determine which Leishmania-species was present would assist medical care providers in determining the appropriate treatment.

3) Currently used methods for the diagnosis of leishmaniasis are either labor/resource intensive and/or require highly trained personnel. The "gold standard" method for the diagnosis of leishmaniasis is the visualization of Leishmania amastigotes by microscopy or the detection of parasites in cell culture. Although both accurate and reliable when conducted by skilled personnel, microscopy is subjective and there are very few individuals with the necessary skill and experience – this method therefore cannot be considered a viable option. Cell culture requires days to weeks for diagnosis, material that is not readily available in a field setting, and highly skilled personnel. Cell culture is therefore not a viable diagnostic option. RT-PCR provides a rapid, reliable diagnostic method; however, it is expensive and requires a reliable cold-chain if the assay is to be used during a deployment. RT-PCR can currently be used to determine if a patient has leishmaniasis; however, other methods such as iso-enzyme analysis are required to determine the species. Development of a MULTI RT-PCR would allow for the rapid detection and simultaneous speciation of Leishmania, thereby providing critical information to health-care providers in a timely manner.

PHASE I: Selected contractor receives reagents for four separate Leishmania-assays from WRAIR and develops a MULTI RT-PCR assay capable of simultaneously detecting and differentiating amongst at least two (2) of the primary species of Leishmania present in the Middle East. Selected contractor must coordinate with the COR for access to required reagents and positive control material from WRAIR. Reagents and positive control material will be provided at no cost to the SBIR contractor. Once developed, the selected contractor provides sufficient amount of assay material to allow the WRAIR to conduct an initial evaluation of the developed assay.

PHASE II: The selected contractor completes development of a prototype MULTI RT-PCR assay that can detect and differentiate all four (4) types of Leishmania (Leishmania-generic, L. major, L. tropica or L. infantum/donovoni/chagasi). Contractor provides sufficient assay material to COR/WRAIR so that comprehensive evaluation of the assay can be conducted. Contractor uses data/feedback from WRAIR to refine assay until performance reaches threshold levels (>90% sensitivity and specificity when compared to cell culture and/or microscopy). Contractor takes final assay and develops field stable reagents that require no cold-chain. The selected contractor conducts stability testing of the field stable reagents using an accelerated schedule whereby the contract will attempt to force the product to fail under a broad range of temperature and humidity conditions and extremes.

PHASE III: The selected contractor provides enough reagents/material to allow for testing of 10,000 samples. This material is used by the COR/WARIR for comprehensive field-testing of the assay to ensure that all requirements have been met. Ii is envisioned that field testing will be conducted at the Navy Medical Research Laboratories in Egypt and Peru, at the U.S. Army Medical Research Unit in Kenya, in Iraq by Army PVNTMED DETS, and at other selected sites. Field testing will be conducted at no cost to the SBIR contractor.

DUAL USE APPLICATIONS: The developed technology could be used by military forces operating in Africa, the Middle East, the Mediterranean basis, and parts of central Asia. Local governments or regional commercial medical centers in the developing countries in this region could use this technology to accurately and rapidly assess the threat from leishmaniasis.

COMMERCIAL APPLICAITONS (SPIN-OFF): Government or commercial medical centers in the Leishmania-endemic regions of the world require cheap, easy-to-use diagnostic assays for the detection of leishmaniasis is sand flies. The development of a field-usable Leishmania-assay would provide an urgently needed device that would be commercially viable.

COMMERCIAL APPLICATIONS (SPIN-ON): Development of a technology that meets the military requirement for a device to detect leishmaniasis could allow for the subsequent development of similar devices for the detection of other diseases of public health and military concern (i.e., leptospirosis or dengue).

TECHNICAL RISK: There is a degree of technical risk involved in this project. Currently existing Leishmania assays do not meet the requirements outlined in this proposal -- the candidate contractor is expected to use innovation and in-house expertise to develop a prototype that meets the needs of the Department of Defense.

ACCESS TO GOVERNMENT FACILITIES AND SUPPLIES: The development of the required diagnostic assay will require support (reagents, Leishmania antibody and antigen, etc.) from the Walter Reed Army Institute of Research in Silver Spring, Maryland. The candidate contractor should coordinate with the COR for any required support prior to the submission of the proposal.

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KEYWORDS: Leishmaniasis, Leishmania, diagnosis, PCR

OSD04-H08 TITLE: Development of a Field-Usable Diagnostic Device for the Detection of Leishmania Parasites in Sand Flies

TECHNOLOGY AREAS: Biomedical, Space Platforms

OBJECTIVE: Adapt state-of-the-art technology to develop a field-usable assay capable of detecting and identifying Leishmania parasites in Sand flies.

REQUIREMENT: To quickly and accurately determine whether sand flies collected during military deployments are infected with the agent that causes leishmaniasis. Leishmaniasis has been a major cause of morbidity in U.S. forces deployed to the Middle East (Iraq, Saudi Arabia, and Afghanistan) since World War II, with over 400 confirmed cases to date during Operation Iraqi Freedom. Since there are no vaccines or prophylactic drugs that can prevent leishmaniasis, the only effective method of preventing the disease is to eradicate the vector or to prevent infected sand flies from feeding on soldiers. Development of a field-usable assay for the detection of Leishmania parasites in sand flies would allow for the accurate assessment of the leishmaniasis threat. This information could then be used to implement an effective sand fly control program. Due to the current critical threat posed by leishmaniasis to US forces deployed to the Middle East for Operation Iraqi Freedom, this effort is a high priority for the DoD.

DESIRED CAPABILITY/CONCEPT OF THE FINAL PRODUCT: We envision a rapid detection assay capable of determining whether sand flies are infected with Leishmania parasites, the causative agent of leishmaniasis. The assay should detect Leishmania-specific antigen OR an alternative marker that is specific for Leishmania. The assay must be rapid (<30 min), one- or two-step format, and stable (storage at 35 degrees C for 2 years). The assay should be able to detect a minimum of 1-infected sand fly in a pool of 25 sand flies, and should be sensitive enough to detect 85% of lab-infected sand flies. The assay must be soldier-friendly (i.e., easy to operate), inexpensive, portable, use heat-stable reagents, and have no special storage requirements.

DESCRIPTION: The ability to quickly identify infectious agents capable of causing disease in military troops is a major component of the Military Infectious Disease Research Program (MIDRP). The leishmaniases are a diverse group of diseases caused by protozoan parasites of the genus Leishmania and transmitted by phlebotomine sand flies. An estimated 12 million people suffer from leishmaniasis with more than a million new cases reported annually. The leishmaniases include a wide spectrum of diseases ranging from the self-healing cutaneous form to a potentially fatal visceral disease. Although vaccines and/or prophylactic drugs are the preferred method of protecting military personnel from infectious diseases, there currently are no prophylactic drugs or vaccines for leishmaniasis. Therefore, the primary method of preventing leishmaniasis is to ensure that soldiers are not bitten by infected sand flies. This is accomplished by implementing an effective prevention and control program that consists of (1) use of Personal Protective Measures (insect repellent, bed nets and permethrin-treated uniforms), (2) use of insecticides to kill adult sand flies, (3) control of disease reservoirs (typically rodents and dogs), and 4) ensuring that all soldiers and the chain-of-command are familiar with the threat.

Leishmaniasis is unique among vector-borne diseases in that it has an extremely long incubation period (the interval between being bitten by an infected sand fly and the development of disease symptoms). This long incubation period provides a unique opportunity to establish a prevention and control program PRIOR to ever seeing a single case of the disease in soldiers. When implemented, an effective prevention and control program should theoretically be able to completely protect soldiers from leishmaniasis.

The severity of the leishmaniasis threat is based on the abundance of infected sand flies. Areas without infected sand flies or with very low numbers of infected sand flies pose minimal risk to US military forces. Conversely, areas with high numbers of infected sand flies pose a severe risk and require aggressive implementation of prevention and control measures. Data from the 520th Theater Army Medical Laboratory (TAML) deployment during Operation Iraqi Freedom (OIF) illustrates the nature of the problem. The 520th TAML found that up to 75% of soldiers stationed at Tallil Air Base in southern Iraq experienced from 50 to >1,000 sand fly bites in a single night. In some units almost 50% of sick call visits were for sand fly bites. Approximately 1 in 60 sand flies was infected with leishmaniasis. When taken together, these data clearly indicate that large numbers of soldiers at Tallil Air Base were probably infected with Leishmania parasites. Several months after this initial data was gathered, the first cases of leishmaniasis from OIF were detected in soldiers stationed at Tallil Air Base. To date, over 400 confirmed cases of leishmaniasis have occurred in US soldiers deployed to Iraq. Each infected soldier must be evacuated to the Walter Reed Army Medical Center where they received up to 28 days of intravenous drug therapy to treat the disease. It is anticipated that over 1,000 cases of leishmaniasis will occur in soldiers deployed to OIF during 2003 and 2004 (LTC Peter Weina, Director, WRAIR Leishmania Diagnostic Laboratory, personal communication).

The 520th TAML used a Real-Time Fluorogenic Polymerase Chain Reaction (RT-PCR) assay to detect Leishmania parasites in sand flies. Although the RT-PCR is an extremely accurate assay that provided invaluable information to deployed forces, RT-PCR requires highly-trained personnel and sophisticated laboratory support (sterile environment, refrigerators, freezers, refrigerated centrifuges, etc.). The 520th TAML and its replacement the Air Force Biological Assessment Team were the only units deployed during OIF with the ability to use RT-PCR. Although the 520th TAML was able to develop an accurate threat assessment of Tallil Air Base and a handful of other locations, difficulties in getting sand fly samples to the 520th TAML in a timely manner limited the amount of data that could be analyzed.

In contrast to the 520th TAML (a one-of-a-kind organization), Army, Navy and Air force Preventive Medicine detachments (PVNTMED DETs) are normally deployed throughout a theater of operations. A primary mission of PVNTMED DETs is to conduct pest control operations. PVNTMED DETS are currently equipped with the Malaria Vec-Test, a field-usable assay for the detection of malaria in mosquitoes. The Malaria Vec-Test allows PVNTMED DETs to accurately conduct their own malaria threat assessment – results from this assessment allow the PVNTMED DETs to rapidly and efficiently implement targeted pest control operations. A principle technical barrier to the accurate detection of leishmaniasis in sand flies is the lack of a device for detecting Leishmania parasites in sand flies that is analogous to the Malaria Vec-Test. Any device that was developed would need to have the following characteristics: (a) one step, b) field-usable, 3) utilizes stable reagents, and 4) has no special storage or equipment requirements.

PHASE I: Selected contractor determines the feasibility of the concept by developing a prototype diagnostic assay that has the potential to meet the broad needs discussed in this topic. Selected contractor must coordinate with the COR for access to required reagents, Leishmania antigen, and Leishmania-infected sand flies from the Walter Reed Army Institute of Research (WRAIR). Reagents, antigen and sand flies will be provided at no cost to the SBIR contractor. A single lot of 100 prototypes is provided to the COR for initial testing at the WRAIR.

PHASE II: The selected contractor provide up to 3 initial lots of 500 prototype assays/lot to the COR -- these initial lots will be evaluated at WRAIR for sensitivity and specificity. Feedback regarding the sensitivity/specificity of each lot of prototype assays will be provided to the contractor – this data will then be used to optimize each subsequent lot of assays. The goal in Phase II is the development of a prototype assay that provides 85% sensitivity and specificity when compared to microscopic examination of sand flies. Once sensitivity/specificity requirements have been met, the selected contractor provides a final lot of 1,000 prototype assays for laboratory confirmation of assay performance characteristics (sensitivity, specificity, positive and negative predictive value, accuracy and reliability). Testing for performance characteristics by WRAIR will be conducted at no cost to the SBIR contract. The selected contractor will also conduct stability testing of the prototype device in Phase II. Stability testing will follow an accelerated schedule where the contract will attempt to force the product to fail under a broad range of temperature and humidity conditions and extremes.

PHASE III: The selected contractor provides 10,000 assays to the COR for comprehensive field-testing to ensure that all requirements have been met. Stability testing will be conducted at the WRAIR by performing simple sensitivity and specificity testing on small lots of the protocols every six months over a 2-year period. It is envisioned that field testing will be conducted at the Navy Medical Research Laboratories in Egypt and Peru, at the U.S. Army Medical Research Unit in Kenya, in Iraq by Army PVNTMED DETS, and at other selected sites. Field testing will be conducted at no cost to the SBIR contractor.

DUAL USE APPLICATIONS: The developed technology could be used by military forces operating in South- and Central America, in Africa, the Middle East, the Mediterranean basis, and parts of central Asia. Local governments or regional commercial medical centers in the developing countries in this region could use this technology to accurately and rapidly assess the threat from leishmaniasis.

COMMERCIAL APPLICATIONS (SPIN-OFF): Government or commercial medical centers and pest control operators in the Leishmania-endemic regions of the world require cheap, easy-to-use diagnostic assays for the detection of leishmaniasis is sand flies. The development of a field-usable Leishmania-assay would provide an urgently needed device that would be commercially viable.

COMMERCIAL APPLICATIONS (SPIN-ON): Development of a technology that meets the military requirement for a device to detect leishmaniasis in sand flies could allow for the subsequent development of similar devices for the detection of other diseases of public health and military concern (i.e., leptospirosis or dengue). In fact, an SBIR written in 1995 by LTC Coleman and subsequently directed by LTC Jeff Ryan resulted in the development of the commercially available Malaria Vec-Test as well as West Nile Virus and Saint Louis Encephalitis Virus assays.

TECHNICAL RISK: There is a degree of technical risk involved in this project. Currently existing Leishmania assays do not meet the requirements outlined in this proposal -- the candidate contractor is expected to use innovation and in-house expertise to develop a prototype that meets the needs of the Department of Defense.

ACCESS TO GOVERNMENT FACILITIES AND SUPPLIES: The development of the required diagnostic assay will require support (reagents, Leishmania antibody and antigen, infected sand flies, etc.) from the Walter Reed Army Institute of Research in Silver Spring, Maryland. The candidate contractor should coordinate with the COR for any required support prior to the submission of the proposal.

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KEYWORDS: Leishmaniasis, Leishmania, Sand flies, diagnosis, devices

OSD04-H09 TITLE: Rapid Determination of Complement Activation in the Battlefield

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop a proof-of-concept, design, develop, build and demonstrate a proteomics chip to rapidly and reliably determine the extent of complement activation in the battlefield. The product will assist medics and health care profssionals to determine whether injured subjects have extensive complement activation and whether the administration of complement activation inhibitors will first limit tissue injury.

DESCRIPTION: Fighting soldiers in the battlefield are subject to multiple conditions including blunt trauma, hemorrhage, shock, limp ischemia, burns and toxic substances. In all conditions there is variable degree of complement activation that contributes to further tissue damage and organ failure. Timely and proper inhibition of complement activation is expected to limit tissue damage. Because complement is central in the protection against infectious agents and extensive inhibition may lead to overwhelming infection and sepsis, it is important to determine the extent of complement activation as a first step for its proportionate inhibition. In addition, since the addition of complement activation inhibitors in the resuscitation fluids reduces the required infusion volume, the determination of the extent of complement activation and the decision to supplement fluids with inhibitors will limit the fluid volumes needed to be carried to the battlefield (1).

This topic falls into the category of developing tools to rapidly determine injury severity, and to decide (triage) the need to add complement activation inhibitors in the resuscitation fluids. The proteomics chip is expected to include parameters to determine which complement factors are involved in a dominant fashion (complement activation pathway determination). The device should allow the establishment of the extent (intensity) of complement activation by determining the rate of depletion of certain complement proteins due to depletion and the magnitude of production of breakdown products such as anaphylatoxins and membrane attack complex that are responsible for organ injury.

The complement activation proteomics chip should be able to assist the health care professional, military and civilian alike, to determine: 1) whether the complement system is activated beyond the normal levels; 2) which pathway is involved; 3) whether complement activation inhibitors should be administered; 4) depending on the activation pathway involved, which inhibitor should be administered; and 5) the dose of the complement activation inhibitor (2).

Because complement proteins are very sensitive to temperature and handling processes, the available laboratory assays in established laboratories cannot be used to meet the battlefield needs.

PHASE I: Phase I will develop a feasibility concept and plan for developing and /or applying various proteomics technologies to determine the extent and intensity of complement activation.

PHASE II: Phase II will develop and demonstrate a working functional prototype of a complement activation proteomics chip. The proteomics chip should be used to determine complement activation in subjects known to have complement activation and determine its sensitivity and specificity using standard laboratory approaches. Study subjects should include patients undergoing resuscitation.

PHASE III DUAL-USE COMMERCIALIZATION: The focus will be on commercializing a human complement activation proteomics chip that is fieldable in both the military and civilian arenas.

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KEYWORDS: Complement activation; trauma; shock; hemorrhage; tissue injury; rapid diagnosis; rapid evaluation.

OSD04-H10 TITLE: <u>Sensor-Based Monitoring and Intervention for Gravity-Induced Loss of Consciousness (GLOC)</u>

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Design and build a neuro-physiological sensor suite to detect gravity induced loss of consciousness (GLOC), almost loss of consciousness (ALOC) and their precursors in real time. The sensor suite should be capable of being embedded within a flight helmet and flexible enough to interoperate with potential cockpit mitigations, such as an ALOC/GLOC-onset alerting system and/or an autopilot recovery safety feature.

DESCRIPTION: Gravity-induced loss of consciousness (GLOC) and almost loss of consciousness (ALOC) continue to be a significant cause of tactical/strike aviation mishaps and loss of aircraft within all of the services. The use of “g-suits” in tactical aircraft provides pilots increased resistance to +Gz exposure; however, these devices do not provide absolute protection against GLOC. In fact, aviation safety continues to emphasize pilot actions, such as an anti-G straining manuevers, prior to a high-G event as a preventative measure for GLOC. GLOC can set in so rapidly during tactical maneuvers that straining alone

is clearly insufficient to prevent GLOC. In addition, ALOC may go unnoticed by a pilot or aircrew, unless a mishap results from the event.
Recent advances in neurophysiological sensor technologies including miniaturization, ruggedization, portability and real time signal processing provide an opportunity to develop brain monitoring technologies for use in operational environments including the tactical cockpit. Recent studies have shown that it is possible to detect cognitive events in real time using such sensor technologies. The present topic seeks applications of these sensors in the detection of and intervention in ALOC/GLOC episodes. Successful proposals to this topic could integrate sensor technologies such as electroencephalography (EEG), functional near-infrared (fNIR) imaging and other physiological sensors into a prototype "flight helmet" to predict, detect, prevent, and recover from ALOC/GLOC. This device would be designed for integration with tactical aircraft cockpit and flight control systems, with such specific functionality as a GLOC onset alert/alarm function and an autopilot recovery mechanism triggered by onset of GLOC.

PHASE I: Conduct a comprehensive review of existing neurophysiological sensor technologies and their suitability for detection of ALOC/GLOC. Conduct a feasibility study on the integration the sensor technologies into the flight-helmet application, and develop a proposed plan for an integrated flight helmet suite.

PHASE II: Design and demonstrate a prototype flight- helmet system for the prediction and detection of ALOC/GLOC. Prototypes should be tested using centrifuge studies in order to demonstrate the ability of the system to survive high G environments and detect onset of GLOC in real-time. Prototypes should be suitable for delivery to the Services.

PHASE III: DUAL USE APPLICATIONS: This topic has many dual use applications, and devices developed could be employed to significantly improve operations in Navy, Marine Corps and Air Force tactical aviation environments. In addition to GLOC, a ruggedized, miniaturized neurophysiological sensor suite could ultimately be used for monitoring and mitigation of other aviation related hazards such as hypoxia or fatigue, and also could be employed for other non-aviation applications involving operator state monitoring

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KEYWORDS: Gravity induced loss of consciousness, GLOC, almost loss of consciousness, ALOC, Aviation Safety, Cognitive State Detection, EEG, fNIR, neurophysiological sensors

OSD04-H11 TITLE: Simultaneous EEG Acquisition and Portable Near Infrared Spectroscopy for Recognition of Traumatic Brain Injury Severity and Outcome Assessments in Far-Forward Military Medical Care

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop light-weight, readily portable near infrared spectroscopy (NIRS) systems in conjunction with EEG acquisition for testing in model systems (experimental brain injury) and ultimate translation to integrated NIRS/EEG for morbidity assessment and seizure detection in human head injury.

DESCRIPTION: Near infrared spectroscopy (NIRS) systems can penetrate non-invasively through the skull and detect/image blood beneath the skull surface and in the cortical layer of the brain. This technology can also be modified for assessment of tissue viability and evaluation of the presence of foreign bodies (shrapnel) or fractured pieces of the skull that may have pushed into and below dura. Such

assessments allow for rapid determinations for treatment (e.g., measures to reduce increases in intracranial pressure). Currently, magnetic resonance imaging (MRI) and computer aided tomography (CAT) scans are the standard tools for determining the presence of foreign objects and bleeding in the cranium such as subdural hematoma and subarachnoid hemorrhage - but the excessive size of imagers/scanners leads to lack of portability and their cost is prohibitive for use in military operational environments and emergency care. With a lower cost, light-weight NIRS system, medical teams have the opportunity to "see" below the skull and make rapid assessments of patient status, and facilitate decisions regarding evacuation and appropriate treatment. Military medical teams have also expressed the need for brain electrophysiological assessments, to evaluate trauma induced seizures (convulsive and non-convulsive) and determine topographic tissue viability. Integration of electrodes, acquisition of the encephalography (EEG) with digital storage and singular analysis with subsequent integration of such a signal with NIRS may give mobile medical personnel/teams a stellar tool for direction in medical care to optimize patient outcomes. While some research efforts have been made in developing NIRS system for TBI detection, in-depth understanding of the relationship between NIRS and TBI is needed to validate its design and then assess, customize and evaluate integration of NIRS and EEG. Protocols and experiments are needed to model, test, and validate a fully functional low cost NIRS/EEG system for meaningful application in TBI assessments. The development of NIRS/EEG technologies will offer the military medical community, and eventually civilian emergency medical care, an opportunity to detect intracranial hemorrhage in fielded soldiers, as well as provide knowledge about concealed foreign objects or displaced skull, reveal swelling/edema, and other injury characteristics while also identifying trauma induced seizures, affording medical workers more time and information to make critical treatment and/or evacuation decisions.
PHASE I: Conduct validation studies in the laboratory for militarily relevant brain injury models, construct theoretical and physical models for preclinical and clinical application, and relate the NIRS measurement with consequences of physical disruption of brain tissue and intracranial bleeding (subdural hematoma or subarachnoid hemmorhage) for optimal detection.

PHASE II: Conduct more in-depth laboratory and clinical studies on brain injuries for NIRS detection of morbidity in brain injury. Develop concomitant measures of NIRS injury detection and EEG acquisition and determine overall usability and accuracy. Develop and validate algorithms for a multimodal device that may be uses both NIRS and EEG assessments for detection of brain injury. Develop prototype device for use in ambulatory environments.

PHASE III DUAL USE COMMERCIALIZATION: The development of portable NIRS/EEG detection systems has application in both military and commercial settings. These highly portable, multimodal NIRS/EEG detection devices under development in this topic will provide information about patient status currently unavailable in remote hospital locations and enable early treatments that may decrease morbidity and increase survival and quality of life after trauma to the head. The technologies under development will find commercial applications in mobile medical environments such as mobile trauma centers, ambulances and rescue helicopters.

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2. Heaton, L, M Smith, et al (2000) "Handheld four wavelength retinal vessel oximeter" Opthalamic Technologies X Proceedings of SPIE Vol 3908

KEYWORDS: Closed head injury, Near infrared spectroscopy (NIRS), subdural hematoma (SDH), EEG, electroencephalogram, remote operational/mobile settings, combat casualty care

OSD04-H12 TITLE: Digital Archive and Access to Lifetime Military Medical Records

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DOD(HA) PEO IM/IT

OBJECTIVE: Design and develop a digital system for archiving paper military medical records and providing secure web-based access to those records for separating or retiring military personnel.

DESCRIPTION: The task is to design and develop a digital system for archiving the contents of the active military medical records file upon retirement or separation of the military member, prior to permanently filing the medical records jacket and its contents at the various military record libraries so that these records and the medical histories they contain can be securely accessed, searched, and datamined via the TRICARE web portable by those authorized to access them.

Upon entry of US military on to active duty, new recruits have created for them, individual paper military medical records. These records accompany the military members and are normally stored at supporting military health system clinics or hospitals wherever they are stationed throughout their military careers. Every health care encounter is supposed to be documented in the military medical record file. Upon retirement or separation, the record is turned in to military personnel managers at the installation where the member separates and is sent to a central military records archive facility. Subsequent access to that record and the medical history it contains by the individual member, by his/her health care providers, or by the Veteran's adminstration is only accomplished via a difficult bureucratic process. Records retrieved by the military or VA for review subsequent to separation are often temporarily or permanently lost. Many service members are relegated to photo copying their active duty military medical records prior to separation to ensure they have access to their military history after separation. These copies are unofficial and cannot or should not be used as a basis for subsequent health care or for decsions on post service medical benefits.

In what may be the most ambitious move yet toward electronic medical records, Kaiser Permanente, the nation's largest nonprofit health-maintenance organization, recently announced plans to spend $1.8 billion to automate its patient files. Kaiser, with 8.4 million members in nine states, said its goal is to have the automated records up and running in three years. With such a system, the HMO would make portions of each patient's records available online to members, who would be able to check recent medical-test results, see their complete immunization history and review their current medications, among other things. To accomplish the electronic shift, Kaiser will purchase a system from Epic Systems Corp., a Madison, Wis. software concern, and abandon a decade long effort to develop such a system itself. Health-care policy experts in recent years have been urging medical institutions to convert their paper records to electronic form as an important step to avoid medication errors and other mistakes caused by incomplete patient information. Electronic systems also facilitate evaluation of individual doctors and the effectiveness of new treatments. But the technology's enormous cost and the difficulty of persuading busy doctors to change the way they practice, as well as privacy concerns, have slowed its adoption.

Within the DOD Military Health System, efforts have been underway for several years to change over to fully digital health care records. While these efforts are nearing fruition via the DOD they do not yet include any provision for incorporating legacy and current paper military records, because the technology to digitize these records in a form which can be efficiently organized and searched by a computer application or datamining program is not apparently available. We are seeking a methodology to scan or otherwise digitize paper military health records in a form which, can not only be viewed as copied documents, but also stored as searchable and dataminable data. Many of the paper records are hand written notes; others are charts and graphs. Digitizing these records beyond mere image reproductions, so that the digital archives can be organize, searched and data mined requires additional research. Natural language processing technology or research may be needed to provide accurate codable interpretations of narrative notes and summaries. Image-based medical records such as X-rays, anatomical photographs, and ECG charts should also be included in the searchable digital medical record. Medical data should be stored in a format that is compatible with both the military health system data standards and internationally accepted medical data standards such as Health Level Seven (HL-7) and Digital Imaging and Communications in Medicine (DICOM). In order to adequately data mine medical histories the medical data and textual narrative summaries, diagnoses, notes, orders, and procedures should be mapped (coded) to the International Classification of Diseases, 9th and 10th editions (ICD-9/10) and Current Procedure Terminology, 4th edition (CPT-4) Coding schemes for medical findings and diagnoses. The Medical data should be secured in accordance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA)

PHASE I: Conduct appropriate research to develop a concept and design a digital system for archiving the contents of the active military medical records file prior to permanently filing the medical records jacket and its contents at the various military record libraries, so that these records and the medical histories they contain can be securely accessed, searched, and datamined via the TRICARE web portable by those authorized to access them. Conduct a feasibility study to validate the concept. Coordinate through the Government COR with the DOD(HA) PEO for Information Management and Information Technology and military health services for access to examples of appropriate military medical records and associated data that would be required to execute Phase II.
The objective of this SBIR topic presents a broad challenge in several different areas of information processing technology. Because of the limited scope of an SBIR, proposers may choose to focus on only one or two of the challenges discussed above.

PHASE II: Develop a prototype system and demonstrate the capability to digitize paper military medical records for archiving such that the medical histories contained in these records can be securely accessed, searched, and datamined via the TRICARE web portable by those authorized to access them.
Implement the system for operational testing within the DOD Military Health System (MHS).

PHASE III: Implement the capability to digitize, store and access via the TRICARE Management Activity (TMA) Web Portal in conjuntion with the DOD TMA and the Veterans' Administration (VA) Health System. Extend the capability to include military dependents and other MHS and VA Health System beneficiaries.

REFERENCES:
http://money.cnn.com/2003/02/04/news/companies/hmo_kaiser.dj/index.htm
http://www.hhs.gov/ocr/hipaa/bkgrnd.html (HIPPA Standards & background)
http://www.hl7.org/ (HL7 Standards & background)
http://medical.nema.org/ (DICOM Standards & background)
http://aspe.hhs.gov/admnsimp/faqcode.htm (ICD-9/10 and CPT-4)
Military Health System data repository (descriptions and meta data):
http://www.tricare.osd.mil/
http://www.tricare.osd.mil/ais/default.htm
http://citpo.ha.osd.mil/index.cfm?body=chcsii
http://www.tricare.osd.mil/policy/tma02pol.htm
http://www.hirs.osd.mil/home/about.html
http://www.tricare.osd.mil/tma/imtr/index.html
http://www.tricare.osd.mil/imtr/jcaho/hpjcaho2.html
The Military Health System (MHS) is essentially a giant HMO operated by the Military services and the DOD TRICARE Management Activity (TMA) to provide both peacetime health care and deployed combat support health care for beneficiaries deemed elligble by the Secretary of Defense:
http://www.tricare.osd.mil/org/tmaorgpg.html
http://www.tricare.osd.mil/plaintalk/plain_talk_2002_01.html
http://www.tricare.osd.mil/plaintalk/
For specific Service (AF, Army, Navy) health systems go to:
https://www.afms.mil/sg/index.htm
http://www.armymedicine.army.mil/armymed/default2.htm
http://navymedicine.med.navy.mil/

KEYWORDS: electronic patient record, digital medical record, digitize, web-based record access, TMA, DOD MHS, Veterans Health System.

OSD04-H13 TITLE: Tool for Dynamically Integrating Military and Civilian Telemedicine and Medical Informatics Systems for Homeland Security

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: DOD(HA) PEO IM/IT

OBJECTIVE: Design a tool which can be used to dynamically integrate diverse military and civilian telemedicine, clinical information and other medical informatics systems to facilitate interaction between military and civilian medical activities responding to homeland security incidents.

DESCRIPTION: Since 9/11/2001 the nation has focused key efforts on planning and building response systems to foreign unconventional attacks on the US Homeland, incidents of terrorism, and natural disasters. Joint and combined medical response among civilian and military health care systems and civilian emergency services organizations is a key component of much of the planning and response organizational efforts. A major obstacle to rapid and efficient integration of military and civilian health care responses is incompatibility among civilian and military computerized health information systems and health data records. There are no strict technical standards for electronic medical records, multimedia health information systems, security of medical records, or for electronic methods of sharing such data among military and civilian health care organizations. Until such standards evolve and are universally adopted, integration of military and civilian telemedicine and medical information systems requires painstaking interfaces to be built between and among systems. The objective of this initiative is to design and build a tool for rapidly integrating military and cilviian health information systems to include digital records, digital images, mulitmedia (audio and video) recordings, data from various medical instruments and pysiological monitors. The research approach can take several paths including design of a telemedicine and medical informatics reference architecture with associated standard modular descriptions that can be universally applied to multisource inputs, a software tool that readily links various data from diverse sources, or via universally accepted information integration tool such as a web browser. The design should provide for quickly configuring a system to pass medical information among existing and emerging civilian and military health information systems such as the DOD TRICARE Composite Health Care System Versions I and II (CHCS I and II), the DOD Oracle Clinical Data Respository, the DOD Digital Information Picture Archiving Communications System (DINPACS), and the Veterans Health Administration System Digital Hospital Information System.

PHASE I. Develop a concept and design a tool that can be used by military and civilian health care personnel to rapidly and dynamically integrate diverse military and civilian telemedicine, clinical informationmilitary and cilviian health information systems to include digital records, digital images, mulitmedia (audio and video) recordings, data from various medical instruments and physiological monitors to facilitate interaction between military and civilian medical activities responding to homeland security incidents. Conduct a feasibility study to validate the concept. Coordinate through government COR with the DOD(HA) PEO for Information Management and Information Technology for access to DOD health care data (test data) and integration with DOD medical information systems that would be required to execute Phase II. Coordinate with applicable civilian health care organizations and facilities for similar access to civilian health care data and civilian medical information systems that would be required to execute Phase II.

PHASE II. Build a prototype of the tool and test the tool within a suitable civilian/military health care setting, begining with forward deployed medical units in a training environement or exercise. Demonstrate the tool as part of a joint military/civilian deployment and/or homeland security exercise or within the DOD Homeland Security Advanced Concept Demonstration (ACTD).

PHASE III. Extend the tool to multiple DOD, VA and civilian health care systems and incorporate local/regional user response grid preparation and training for executing integrated military/civilian medical responses to homeland security incidents.

KEYWORDS: teleconsultation, telemedicine, medical information integration, medical homeland security, clinical information, medical decision making, medical collaboration

OSD04-H14 TITLE: Develop Portable Near Infrared Technology for Detection of Pulmonary Function Following Blast Injury

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Model and validate pulmonary function following blast injury; develop portable near infrared spectroscopy (NIRS) systems for blast injury detection.

DESCRIPTION: The primary injury in response to shock waves following detonation of explosives occurs in the lung (5). Consequences of blast injury in lung can include pulmonary contusion, hemorrhagic edema, hemo-pneumothorax, and circulatory depression. In operational or remote settings, immediate evaluation of lung function following blast injury is limited to the assessment tools at hand. It is vital that a detection device be developed that can rapidly identify lung function following blast injury, to facilitate decisions regarding appropriate far forward medical care. The method of intervention selected may greatly impact final outcome and survivability. Near infrared spectroscopy (NIRS) can penetrate non-invasively through the parts of the body and detect/image blood beneath the surface. If NIRS were able to be used to measure lung function, it would be a more portable and safe alternative than X-rays, magnetic resonance imaging (MRI) and computer aided tomography (CAT), as well as less costly, and could readily be used in operational environments. NIRS technology can also be modified for assessment of tissue viability and evaluation of the presence of foreign bodies (shrapnel). With the potentially low cost and small size nature of an NIRS system, it can afford medical teams an opportunity to assess lung damage, and make rapid assessments of patient status, and facilitate decisions regarding evacuation and appropriate treatment. Adult respiratory distress syndrome (ARDS) commonly occurs in blast injury, but is difficult to detect based on symptoms. To our knowledge, use of NIRS technology to evaluate lung function has not been evaluated. Protocol and experiments are needed to model, test, and validate NIRS assessment of lung damage following blast injury. The development of NIRS technologies will offer the military medical community an opportunity to detect pulmonary function on site and should afford medical workers more time to make critical decisions about whether or not a patient needs to be evacuated from the current location.

PHASE I: Conduct preliminary studies in laboratory to model blast injuries, to validate the theoretical models, and to relate the NIRS measurement with pulmonary function. Based on the laboratory experiments, evaluate the design considerations for an NIRS device that could be used by a variety of medical workers.

PHASE II: Conduct more in-depth laboratory and clinical studies on blast injuries. Develop prototype device for use in ambulatory environments. Conduct testing to determine usability and accuracy.

PHASE III DUAL USE COMMERCIALIZATION: The development of portable NIRS systems has applications in both military and commercial settings. The NIR devices under development in this topic will provide information about patient status currently unavailable in remote hospital locations and enable early treatments. It is probably only a matter of time until terrorists in this country also use suicide bombers and roadside IED, which will then affect the civilian as well as the military population. The technologies under development will find commercial applications in mobile medical environments such as mobile trauma centers, ambulances and rescue helicopters.

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4. Januszkiewicz AJ, Mayorga MA (1994). Nitrogen dioxide-induced acute lung injury in sheep, Toxicology, 89, 279-300.
5. Guy RJ, Glover MA, Cripps NPJ (1998). The pathophysiology of primary blast injury and its implications for treatment. JR Nav Med Serv. 84: 79-86.
6. Heaton, L, M Smith, et al (2000) Handheld four wavelength retinal vessel oximeter. Opthalamic Technologies X Proceedings of SPIE Vol 3908

KEYWORDS: Blast injury, Near infrared spectroscopy (NIRS), lung injury, pulmonary, remote operational/mobile settings

OSD04-H15 TITLE: Armed Services Blood Program (ASBP), Blood Reserve Availability Surveillance System (BRASS)

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: The Objective of the ASBP BRASS is to enhance the current inventory management system, Joint Medical Asset Repository (JMAR) to provide global near-real time surveillance of military blood inventory, supplies, and needs. In addition to the existing computer data "push" configuration, ASBP BRASS would also allow all users to manually enter data via a web-base system. This capability, once developed, could be extended in SBIR Phase III to aid in surveillance of the National Blood Reserve, with civilian and other Federal agencies participating in the central transactional database.

DESCRIPTION: The functions of this enhancement system would be to offer blood program component elements the ability to input data for various blood and blood product types. These data would be warehoused in JMAR. They could then be visualized using Geographic Information Systems technologies and other dashboard metrics, allowing program and preparedness managers to monitor the availability of blood and blood products on a region-by-region basis.

PHASE I: Conduct Research and Systems Design;
a. Conduct research into the efficacy of a web-based collection system, and the ability to allow users to manually input inventory data into the central repository, from other electronic platforms, and across various information networks.
b. Develop one or more design concepts for such a system to creatively overcome technical and policy environment challenges and to support the surveillance of blood reserve availability.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility of the system in a broad scale technical environment.

PHASE III DUAL USE APPLCATIONS: This system would have applicability in military and/or civilian organizations where automated surveillance and notification of asset inventory levels is critical to meeting mission requirements.

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3 - Nightingale, Stephen D., MD, Executive Secretary, Advisory Committee on Blood Safety and Availability, U.S. Department of Health and Human Services, Remarks Regarding Monitoring of Blood Product Demand, 23 August 2001.
4 - Wallace, Edward L., PhD, Monitoring the Nation's Blood Supply, Transfusion, Volume 43, Issue 3, Page 299, March 2003.

KEYWORDS: Surveillance, Pattern Analysis, Decision Making, Preparedness

OSD04-H16 TITLE: Armed Blood Services Program, Bloodborne Pathogen and Donor Deferral Early Warning System

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: The Objective of the Armed Blood Services Program, Bloodborne Pathogen and Donor Deferral Early Warning System, would be to identify indicators and provide early warning of any increase in the detection of bloodborne pathogens in the DoD blood supply, and any increase in blood donor deferrals for identified criteria. Both of these could be indicators of larger national health issues and warrant further investigation. This capability, once developed, could be extended in SBIR Phase III to aid in surveillance and monitoring of pathogen and donor deferral activity in the national blood supply as well.

DESCRIPTION: The functions of this centralized electronic system would be to offer blood program component elements the ability to input blood test and donor deferral data into a central data repository. These data could then be analyzed on an ongoing basis with results visualized using Geographic Information Systems, GIS, technologies to enable program and national health managers to monitor any increase in the presence of bloodborne pathogens or increased donor deferral activity on a region-by-region basis. Early warning indicators of pathogen manifestations and deferral activity would be of importance to both national health and blood inventory management personnel.

PHASE I: Conduct Research and Systems Design;
a. Conducted research into the location of test and/or deferral data, as it currently exists, either locally at program sites in site specific systems, or collectively in systems such as the Defense Blood Standard System (DBSS) and/or the Joint Medical Asset Repository (JMAR).
b. Conduct research to determine baseline test results and deferral rates based on empirical data.
c. Conduct research into the efficacy of a web-based collection system, and the ability to either push program test and donor deferral data, and/or allow users to manually input these data into the central repository, from other electronic platforms, and across various information networks
d. Develop one or more design concepts for such a system to creatively overcome technical and policy environment challenges and to support the surveillance and early warning of bloodborne pathogens and donor deferral activity.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility of the system in a board scale technical environment.

PHASE III DUAL USE APPLCATIONS: This system would have applicability in military and/or civilian organizations where automated surveillance, tracking and notification of infectious disease manifestations through increased bloodborne pathogen positive test results, and/or donor deferral activity are needed.

REFERENCES:
1- Food and Drug Administration Guidelines published in the Code of Federal Register.
2 - Walter Reed Army Institute of Research, DOD-Global Emerging Infections Surveillance and Response System - Addressing Emerging Infectious Disease Threats: A Strategic Plan for the Department of Defense, Washington, DC. 1998.
3 - Office of the Director, CDC, Revised Final FY 1999 Performance Plan And FY 2000 Performance Plan, IV. Infectious Diseases, (Performance Goal: Develop and strengthen epidemiologic and laboratory methods for detecting, controlling, and preventing infectious diseases), 12 January 2000.
4 - CDC, Emerging Infectious Diseases, Special Issue – Blood Safety, Vol. 4 No.3, July – Sep 1998.

KEYWORDS: Surveillance, Early Warning, Infectious Disease, National Health, Pattern Analysis, Decision Making, Preparedness

OSD04-H17 TITLE: Development of a Hemostatic Wound Dressing Incorporating Lyophilized Platelets

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop an advanced hemostatic dressing that incorporates lyophilized (freeze-dried) platelets, such that the dressing will significantly control both venous and arterial hemorrhage in less than two minutes, reduce bleeding time, release platelet-derived wound healing factors in a sustained manner, and be safe to use on any soldier. Development of such a hemostatic dressing supports several subareas of the DoD's Biomedical Technology Area Plan for Combat Casualty Care.

DESCRIPTION: Considerable progress in techniques for the management of life threatening arterial and venous bleeding has been made recently. Furthermore, advances in the technology of blood and blood product storage have resulted in several different methods for the lyophilization (freeze-drying) of platelets. Platelets are a critical component in the clot formation cascade vital for cessation of hemorrhage. They contain numerous growth, wound healing, and hemostatic factors, and provide a matrix for clot formation and wound repair. Platelet-rich plasma (PRP) is currently used in oral and maxillofacial surgery as a gel to improve wound healing and hemostasis in bone and soft tissue grafts, as well as an alternative for fibrin glues. The utility of lyophilized PRP as a surgical adjunct in a field hospital setting is currently being studied. The purpose of this SBIR is to combine these two fields, using the existing technology of platelet lyophilization incorporated into a field dressing for use by a far forward soldier. The resulting dressing would be stable at operational temperatures (-30° to 150°F), would have a long shelf life, would not require special storage conditions (i.e., refrigeration), and would be simple enough for any soldier to use. The product would require only the moisture of the wound area to reconstitute the platelet product and initiating clot formation. The dressing would be functional in a variety of dressing sizes, such that larger dressings could act as compressible bandages while small patches could be used to repair noncompressible hemorrhage. FDA approval of the device is critical to the success of the dressing, and the contractor will be required to demonstrate significant progress towards submission of an IND for this product. Contractor innovation will be actively encouraged.

PHASE I: Demonstrate a technique for lyophilizing platelets that results in minimal damage to platelet morphology and function. Evaluation of Phase I efficacy will be accomplished by assessing platelet morphology, biochemical status, aggregation time, and presentation of surface markers of platelet activation for reconstituted, lyophilized platelets versus control platelets.

PHASE II: Develop a prototype hemostatic dressing that incorporates lyophilized platelets for use in ambulatory environments. Conduct testing with animal models of both external and internal hemorrhaging and demonstrate efficacy versus current hemostatic dressings.

PHASE III DUAL-USE COMMERCIALIZATION: This product can be used in all echelons of military and civilian medical care. Any situation where uncontrolled hemorrhage from trauma or surgery could result in substantial morbidity and mortality would benefit from the application of such a hemostatic dressing. Furthermore, the lyophilization technology developed for this dressing will promote the progression towards long-term storage of platelets, which would be logistically and financially beneficial to both military and civilian hospitals for transfusion purposes.

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KEYWORDS: platelet rich plasma, PRP, lyophilization, hemostasis, wound, dressing, hemorrhage

OSD04-H18 TITLE: Armed Blood Services Program (ASBP), Donor Relationship Management System (DRMS)

TECHNOLOGY AREAS: Biomedical

RATIONALE: The Armed Services Blood Program is tasked with collecting, testing, producing, and positioning adequate blood and blood product supplies for use in combat casualty care and/or ongoing military operational medicine. As such, it is important to engage blood donors, the source of its blood supply, in an ongoing relationship with blood Program elements for the purpose of turning one-time donors, into ongoing, repeat donors. Repeat blood donations are known to cost less than first-time donations, and are less likely to result in unusable blood products due to donor deferral action and/or positive infectious disease test markers. Such factors, therefore, make repeat donations important to ASBP's support to combat casualty care, ongoing military operational medicine, and control of infectious diseases spread through blood transfusion.

It is surmised that the implementation of a commercially available off-the-shelf (COTS) Relationship Management software product could result in increased repeat donations. Such a tool could support the relationship between Blood Donation Center (BDC) personnel and potential donors through the initial and repeat donation processes. It would aid blood donation recruiters and other BDC personnel in shepherding donors through the recruitment, eligibility/screening, donation, and feedback portions of the initial donation experience. Then, the tool would support the BDC in its efforts to establish an ongoing relationship with donors, particularly highly valuable donors of special blood types and/or apheresis donors. It would also allow donors themselves to manage their relationship with the Donor Center through customer self-service options—all to support the increase of repeat, higher quality blood donations.

However, there is some question as to whether a COTS system can increase repeat, high quality donations for the following reasons:

1. Managing relationships between the FDA regulated, and separately operated Army, Navy, and Air Force Service Blood Programs and blood donors would be quite different than managing typical, commercial customer/supplier relationships. Therefore, it is questionable that the COTS functionality would support the Program effectively.
2. The unique Service- and/or site-specific regulations and instructions regarding donor recruitment and engagement raise questions as to the ability of COTS functionality to meet Program requirements.
3. The unique nature of the blood donor populations that the Service Blood Programs attempt to penetrate, and the non-homogeneity of these groups, (including Active Duty, Family Members, Reservists, Retirees, and DoD Civilian personnel) raises questions as to the ability of a COTS product to actually raise repeat donations for the Program.

OBJECTIVE: The objective of the Armed Blood Services Program, Donor Relationship Management Evaluation and Pilot is to determine if the use of a COTS Donor Relationship Management System in the Armed Services Blood Program environment would increase repeat donations, and have a resulting positive impact on combat casualty care, ongoing military operational medicine, and the control of infectious diseases spread through blood transfusion.

DESCRIPTION:

PHASE I: Conduct Requirements Research, Define Functionality, and Evaluate COTS

a. Conduct research into the best practices employed by civilian blood community organizations, and/or other voluntary donor organizations, to enhance the ongoing relationship between donors and the organization.
b. Conduct research into the unique policies and procedures of the ASBP and the Service Blood Programs regarding engagement with blood donors.
c. Develop one or more design concepts for such a system to creatively overcome technical and policy environment challenges and to support the identification of key donor relationships, and increase the available blood supply.
d. Conduct and document research into the ability of existing COTS Relationship Management products to meet the functional and technical requirements of the ASBP donor relationship environment.

PHASE II: Obtain Software, Conduct Pilot, Analyze Results

a. Obtain the software that best meets functional requirements.
b. Plan and conduct a pilot of a Donor Relationship Management System in an active ASBP Blood Donation Center environment.
c. Conduct testing to prove feasibility of the system in the ASBPO technical environment.
d. Conduct testing and analysis to determine the impact of the use of the system on the number of repeat donations for the test BDC.

PHASE III: DUAL USE APPLICATIONS

This system would have applicability in any military and/or civilian organization where improving the relationship between voluntary donors and recipient organizations would result in increased donations.

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KEYWORDS: Relationship Management, Self-Service, Blood Supply Availability

OSD04-H19 TITLE: Next-Generation Antibiotics

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: There is a growing national crisis in the treatment of infectious diseases driven by the dramatic rise in pathogen multi-drug resistance (MDR). Worry grows for both theater-specific diseases, as well as hospital-borne pathogens. Costs related to MDR are estimated to be in excess of $5B / year. The problem may be mitigated in, at least, three ways: 1) developing methods that allow us to restore the utility of antibiotics already approved for clinical use; 2) exploring methods that inhibit the development of antibiotic resistance; and 3) using novel methodologies that avoid the classical small molecule lock and key fit approach in drug design that is rapidly overcome by mutation and natural selection. Systemic, prophylactic and topical capabilities are sought.

DESCRIPTION: In the first instance, mobile genetic elements (MGEs) are known to provide selective advantages for microbial communities. These include key roles in cellular uptake, metabolism and growth; interaction with eukaryotic hosts; and genomic modification. It is also known that MGEs are often critical to antibiotic resistance. Frequently, resistance genes are located directly on the MGEs. Methods that cause the elimination of MGEs (e.g. processes that might mimic the natural process of plasmid elimination) can be exploited to restore the full functionality of previously approved pharmaceuticals. In the second instance, critical proteins are often required by bacteria to mutate their genomes in order to evolve resistance to antibiotics. Proteins required by the "SOS" response can serve as drug targets. Inhibitors of such target proteins may reduce the emergence of resistance by several orders of magnitude. The use of inhibitors as co-drugs would serve to avoid the development of antibiotic resistance. Lastly, classical procedures for antibiotic design put strong emphasis on understanding the lock and key fit of a putative antibiotic in its targeted binding pocket. Resistance develops rapidly driven by mutation and natural selection. We seek supramolecular structures which possess a large combinatorial space to target nanoscale membrane domains. If resistance should develop to a specific structure, combinatorial diversity can be exploited to overcome resistance. Offerors are asked to carefully focus their efforts. Please select from among the following military relevant pathogens: food borne illnesses and diarrheal diseases (diarrheagenic E. coli, Salmonella, and Campylobacter); wound infections (especially Acetinobacter); tularemia (Francisella tularensis); Q-fever (Coxiella burnettii); and brucellosis (Brucella abortus). There is growing interest, as well, in the development of post-exposure chemotherapeutics for such biological warfare agents as anthrax (Bacillus anthracis) and plague (Yersinia pestis).

PHASE 1: Identify lead compounds by in vitro selection and optimization that function as novel antibiotics, or as compounds that eliminate or block the onset of resistance to current antibiotics.

PHASE II: Promising candidates will be subjected to initial efficacy and toxicological examination in laboratory animals. Further develop and optimize lead compounds for animal efficacy by examining absorption, distribution, metabolism and excretion in rodents. Examine efficacy models with selected pathogens in rodents involving protection against sepsis following lethal pathogen injections, as well as protection against thigh infection following IV/IP applications of pathogens.

PHASE III DUAL USE APPLICATIONS: (1) More than 90% of Staphylococcus aureus strains are now resistant to penicillin, methicillin, and other related antibiotics. (2) There is an alarming rise in the incidence of enterococci (the streptococcus that is the most common cause of hospital-acquired infections) now resistant to vancomycin, often the last weapon for defeating these pathogens. (3) As many as 40% of strains of pneumococci in some parts of the US are now partly or completely resistant to penicillin and related antibiotics. (4) And concern grows, likewise, for the successful treatment of Pseudomonas aureginosa and the hemolytic streps.

KEYWORDS: antibiotics; multi-drug resistance; mobile genetic elements; SOS-response; supramolecular molecules