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)
Program Description

Introduction

The Deputy Under Secretary of Defense (Science & Technology) SBIR Program is sponsoring three technology area initiatives this year, Energy & Power, Cognitive Readiness for Transformational Knowledge Systems, and Wireless Technology. We are also co-sponsoring two additional technology areas, biomedical technology and information technology for military health systems, with Defense Health Affairs.

All three services and the Special Operations Command 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 Army, Navy and Air Force 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, abstract, appendices, company commercialization report and their firm's technical and cost proposal form electronically. In addition, a signed copy of the entire proposal should be mailed to the service point of contact identified in the topic. Please refer to the DoD SBIR/STTR Proposal Submission Website, at http://www.dodsbir.net/ and http://www.dodsbir.net/submission/SignIn.asp for electronic submittal of proposals. If you experience problems uploading 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/STTR Proposal Submission Website allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Proposal and Company Commercialization Report. We **WILL NOT accept any proposals which are not submitted through the on-line submission site.** The hard copy submission is not considered a replacement for the on-line submission, it is only considered a signed copy. The submission site does not limit the overall file size for each electronic proposal. However, file uploads may take a great deal of time depending on your internet server connection speed. If you experience problems uploading your proposal, call the help desk (toll free) at 1-866-724-7457. You are responsible for performing a virus check on each proposal 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, DoD Components 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 DoD 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 DoD Program presented in this solicitation strives to encourage technology transfer with a focus on advanced development projects with a high probability of commercialization success, both in the government and private sector. 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.

The topics are presented in five sections, corresponding to the technology areas: Energy & Power, Cognitive Readiness for Transformational Knowledge Systems, Wireless Technology, biomedical and information technology for military health systems. The topic descriptions, that follow this program overview section, are listed below.

The nine Energy and Power Topics follow this section and are:

- OSD02-EP01 High Performance, Compact Capacitor for Pulse Forming Networks by Air Force Research Laboratory, WPAFB
- OSD02-EP02 High Current & Voltage Diode for Power Switching by the Office of Naval Research
- OSD02-EP03 High Temperature Control Circuitry by the Army Research Laboratory

- OSD02-EP04 Phase Change Cooling for Harsh Environments by Air Force Research Laboratory, WPAFB
- OSD02-EP05 Thermo-Voltaic Power Sources by the Army CECOM
- OSD02-EP06 Nano- Structured Electrodes and Electrolytes for High Energy and Power Density Rechargeable Li and Li-Ion Batteries by the Office of Naval Research
- OSD02-EP07 High Efficiency Fuel Cell Reformer for Logistics Fuels by the Office of Naval Research
- OSD02-EP08 Small Scale Fuel Cells for Ground Personnel by the Army Research Laboratory
- OSD02-EP09 Thermionic Power Source Technology by the Air Force Research Laboratory, WPAFB

The fifteen Cognitive Readiness for Transformational Knowledge Systems Topics are:

- OSD02-CR01 Warrior Readiness for Coalition and Collaborative Teams, Army Research Institute
- OSD02-CR02 Warrior Cognitive Skills Assessment Battery, Army Research Institute
- OSD02-CR03 Dismounted Infantry Situational Awareness Assessment in Virtual Simulations, Army Research Institute
- OSD02-CR04 Automated Analysis of Communications from Synthetic Environment Exercises, Army Research Institute
- OSD02-CR05 A Load Expert System, Incorporating an Advanced Biodynamics Model into Load Cost Functions and Development of Load Utility Functions, Natick Soldier Center
- OSD02-CR06 Integration of Behavior Moderators into Cognitive Performance Models for Assessing Cognitive Readiness, Natick Soldier Center in collaboration with Army Medical Research MRMC
- OSD02-CR07 Measuring Multi-tasking Ability, Office of Naval Research
- OSD02-CR08 Information Delivery Configuration for Augmented Warrior Readiness, Air Force Rome Laboratory
- OSD02-CR09 Real-time Simulation Network and Human Performance Measurement Device for Distributed Mission Training (DMT), Air Force Research Laboratory
- OSD02-CR10 Accommodation Engineering and Decision Aide (AEDA), Air Force Research Laboratory
- OSD02-CR11 Identifying and Capturing the Cognitive Demands Imposed by New Systems, Air Force Research Laboratory
- OSD02-CR12 Application of Culturally Specific Aspects of Human Behavior to Adversarial Decision-Making, Air Force Research Laboratory in collaboration with Natick Soldier Center
- OSD02-CR13 Design of Sharable Content Objects with Return on Investment, Naval Air Warfare Center
- OSD02-CR14 Multi-Modal Visualizations for Virtual Environment Training Systems, Naval Air Warfare Center
- OSD02-CR15 Web-based Game Design Advisor, Naval Air Warfare Center in collaboration with Army Research Institute

The four Wireless Technology Topics and Service Laboratory Executive Agents to manage the SBIR topics in this technology area are:

- OSD02-WT01 Develop Wireless LAN Design & Validation Tools, Navy SPAWAR
- OSD02-WT02 Intrusion detection for 802.11 networks, Navy NSWC, Crane
- OSD02-WT03 Wireless LAN Design Tools, Navy NSWC, Crane
- OSD02-WT04 Self-Configuring Hub-less Wireless Network , Naval Sea Systems Command and NSWC, Dahlgren

The Defense Health Biomedical Topics are:

- OSD02-DH01 Life Sign Decision Support Algorithms for Warfighter Physiological Status Monitoring (WPSM), Army Medical Research Acquisition Activity TATRC
- OSD02-DH02 Non-invasive, Transdermal, Near Infrared Glucose Monitor, Army Medical Research Acquisition Activity TATRC
- OSD02-DH03 Medical Modeling & Simulation - Advanced Ureteroscopy Simulation Workstation for Medical Training, Army Medical Research Acquisition Activity TATRC
- OSD02-DH04 Non-invasive Human Metabolic Status Monitor, Army Medical Research Acquisition Activity TATRC
- OSD02-DH05 Monitoring the Warfighter, Army Medical Research Acquisition Activity USARIEM
- OSD02-DH06 Computer Based Simulation Technology for Training Technical Skills in Medicine, Army Medical Research Acquisition Activity USARIEM
- OSD02-DH07 Effectively Communicating Medical Risks, Office of Naval Research
- OSD02-DH08 SOF Critical Care Medical Tools, Special Operations Command in collaboration with DARPA
- OSD02-DH09 Global treatment Protocol Course via Advanced Distributive Learning, Air Force Research Laboratory
- OSD02-DH10 Generative, knowledge-based Approaches for Rapid Development of Simulation-based Medical Training, Air Force Research Laboratory

The Defense Health Information Technology for Military Health Systems Topics are:

- OSD02-DH11 Cognitive Integrated Medical Data Display System, Army Research Command TATRC

- OSD02-DH12 Medical Logistics Information Data Mining for Business Intelligence, Management of Supply Chain Operations, and Early Identification of Critical Events/Conditions, Army Research Command TATRC
- OSD02-DH13 Health Information Data Mining for Early Identification of Bioterrorism, Army Research Command TATRC

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 these 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 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. Proposers are encouraged to consider whether the research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other.

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. 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 considered. 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 (Government or 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. Private sector investments will also be considered for ***Phase II Plus*** funding. ***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. 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 and a signed hard copy should be mailed to the address identified for this purpose in the topic description section. 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 prohibited 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, abstract, appendices, commercialization report and their firm's technical and cost proposal form electronically. In addition, a signed copy of the entire proposal should be mailed to the service point of contact identified in the topic. Please refer to the DoD website http://www.dodsbir.net/submission/SignIn.asp for electronic submittal of proposals. If you experience problems uploading your proposal, call the help desk (toll free) at 866-724-7457. Proposal Cover Sheets along with the Technical Proposal, Cost Proposal, and Company Commercialization Report must be submitted electronically through the DoD SBIR/STTR Proposal Submission Website. 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, Proposal and Company Commercialization Report. We **WILL NOT accept any proposals which are not submitted through the on-line submission site.** The hard copy submission is not considered a replacement for the on-line submission, it is only considered a signed copy. The submission site does not limit the overall file size for each electronic proposal. However, file uploads may take a great deal of time depending on your internet server connection speed. If you experience problems uploading your proposal, call the help desk (toll free) at 866-724-7457. You are responsible for performing a virus check on each proposal 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.

Deputy Under Secretary Science and Technology Focus Area
Energy and Power

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:

- OSD02-EP01 High Performance, Compact Capacitor for Pulse Forming Networks by Air Force Research Laboratory, WPAFB
- OSD02-EP02 High Current & Voltage Diode for Power Switching by the Office of Naval Research
- OSD02-EP03 High Temperature Control Circuitry by the Army Research Laboratory
- OSD02-EP04 Phase Change Cooling for Harsh Environments by Air Force Research Laboratory, WPAFB
- OSD02-EP05 Thermo-Voltaic Power Sources by the Army CECOM
- OSD02-EP06 Nano- Structured Electrodes and Electrolytes for High Energy and Power Density Rechargeable Li and Li-Ion Batteries by the Office of Naval Research
- OSD02-EP07 High Efficiency Fuel Cell Reformer for Logistics Fuels by the Office of Naval Research
- OSD02-EP08 Small Scale Fuel Cells for Ground Personnel by the Army Research Laboratory
- OSD02-EP09 Thermionic Power Source Technology by the Air Force Research Laboratory, WPAFB

OSD 02.2 SBIR TOPICS

OSD02-EP01 **TITLE:** High Performance, Compact Capacitors for Pulse Forming Networks

DoD Critical Technology: Capacitor Dielectrics

MAIL PROPOSAL TO: Air Force Research Laboratory
Propulsion Directorate
ATTN: Laureen Regazzi, AFRL/PROB
1950 Fifth Street
Wright-Patterson AFB, OH 45433-7251 Phone: 937-255-1465

OBJECTIVE: Develop state-of-the-art, high performance capacitor dielectrics. 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). State-of-the-art concepts should primarily include novel dielectrics with very high voltage breakdown strengths (>20KV/mil), and a low loss (<1%) capability to enable capacitive electrical energy storage that can yield ten's of nanosecond bursts at hundred's of KV-level power for repetitively pulsed systems. Emphasis is also on weight and size reductions for the pulse power capacitor device/concept.

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 the necessary short pulses of energy needed to energize loads such as directed energy, and kinetic energy weapons and high power microwaves. Therefore, research objectives include special emphasis on thin dielectrics with an extremely high voltage breakdown strength (> 20KV/mil), a dielectric constant greater than 3, and low loss (<1%). Attention to thermal management issues within the capacitor device is critical due to a need for increased life (>10,000 shots), increased pulse repetition rates to > 100 pulses per second (pps), and high voltage reversal tolerance (>50%); interconnects, packaging and manufacturability issues are also to be highlighted. 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. Therefore, candidate proposals shall address primarily novel and innovative high energy density dielectrics, and may include impregnant development and/or high-density packaging concepts and/or manufacturing technologies.

PHASE I: Demonstrate innovative capacitor approaches with substantial improvement in capacity, voltage breakdown strength, and dissipation factor. Prototype laboratory capacitors should be fabricated and tested to demonstrate the feasibility of the technology.

PHASE II: Demonstrate development of prototype capacitor components using innovative dielectric materials/impregnants, advanced high density packaging, manufacturing technology or a combination thereof.

PHASE III DUAL USE APPLICATION: 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) T.L. Metzger, "From Dreamworld to Real world: Electromagnetic Guns", Aerospace Defense News, Nov/Dec. 1990.

2) F.W. MacDougall, D.C. Howe, and P. Winsor, "High Energy Density Pulsed Power Capacitors," in Proc. IEEE Pulsed Power Conf., Albuquerque, MN, July 28-Aug. 1, 1991,pp. 79-83.

3) D.G. Ball and T. R. Burkes, "PFN Design for Time Varying Loads," in Proc. 1976 IEEE Power Modulator Symp., New York, Feb. 4-5, 1976, pp. 156-162.

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) L. R. Edwards, "Reliability Performance of Pulse Discharge Capacitors", 17th Capacitor and Resistor Technology Symposium, Jupiter, FL, March 24-27, 1997, pp.292-297.

6) Yializis, A. Boufelfel, D. Stahler, "Acrylate/PPS Films for High Temperature Capacitor Applications", 21st Capacitor and Resistor Technology Symposium, St. Petersburg, FL, March 25-30, 2001, pp. 311-316.

KEYWORDS: Dielectrics, Polymers, Capacitors, Impregnants, Pulse Forming Networks, Marx Bank, Power Electronics

OSD02-EP02 **TITLE:** High Current and Voltage Diodes for Power Switching

DoD Critical Technology: Power

MAIL PROPOSAL TO: Office of Naval Research
ATTN: Mr. Steven Jaeger
ONR Code 333, BCT-1 (Room 507-10)
800 North Quincy Street
Arlington, VA 22217-5660 Phone: 703-696-5354

OBJECTIVE: Develop diodes based on wide bandgap semiconductors capable of handling high currents and voltages for power switching circuits for electric vehicles.

DESCRIPTION: Freewheeling diodes are used in an array of power control and distribution circuits. High voltage silicon-based diodes suffer from significant reverse recovery peak current and recovery charge, which contribute to turn-on loss for the power switch, and to electromagnetic interference (EMI) in power converters. A new class of high power diodes is becoming available based on SiC wide bandgap materials that make use of the 10 fold increase in critical breakdown field of SiC over Si. In addition, continuous improvements in GaN material quality, primarily driven by optoelectronics applications, opens the door of GaN-based high power diodes. With initial SiC Schottky diodes now commercially available at 600 V and 1200 V, but only at modest current (10 A), a critical need exists for the realization of high total current (>100 A) high voltage (1200 V, 4500 V, 7500 V, and 13500 V) wide bandgap diodes. The voltage rating and switching speed will be determined by the application and may require either a Schottky or PIN diode approach. This topic seeks to produce the technology for delivering packaged, high total power diodes able to operate in harsh environments. In particular, the diodes and package must be optimized for operation up to at least 200 C and must reliably withstand avalanche.

PHASE I: Develop a feasibility concept for SiC or GaN Schottky or PIN diodes with significant improvement over those commercially available, e.g. exceeding 150Amps at 600 Volts, blocking Voltage, 100 Amps at 1200 Volts, or 10 Amps at 3300 Volts, and capable of 200C operation and 100 kHz switching.

PHASE II: Demonstrate SiC or GaN Schottky or PIN diodes including all the critical processing technology, and potential for hybrid packaging with Si switching devices (e.g. IGBT).
Optimize one or more voltage rating of high current diodes, fully packaged with demonstrated 200 C operation. Demonstrate temperature dependence of switching characteristics and stable device operation of >100 hrs.

PHASE III DUAL-USE COMMERCIALIZATION: Manufacture selected packaged diode for incorporation into power switching circuits for DoD applications.

REFERENCES:

1) See papers in Power Semiconductor Devices & ICs, 2001. ISPSD '01. Proceedings of the 13th International Symposium on, 4-7 June 2001, Osaka, Japan , 2001, ISBN: 4-88686-056-7 IEEE Catalog Number: 01CH37216

2) Presentations made at High-Power Solid-State Electronics: http://www.darpa.mil/MTO/HPSS/Presentations/megawatt/fall_presentation/Fall_index.html

KEYWORDS: Power Diodes, Wide Bandgap

OSD02-EP03 **TITLE:** High-Temperature Control Circuitry

DoD Critical Technology: Compact High-Power Density Power Components

MAIL PROPOSAL TO: US Army Research Laboratory
ATTN: AMSRL-DP-T (Dean Hudson)
2800 Powder Mill Road
Adelphi, Maryland 20783-1197 Phone: 301-394-4808

OBJECTIVE: Develop high-temperature circuitry to control power boards that are implemented using the emerging high-temperature silicon carbide (SiC) technology power switches .

DESCRIPTION: The first high-temperature motor inverter that operates at a heat sink temperature of 150 C has been demonstrated this year. Although the power board was implemented using high-temperature current-controlled silicon carbide

(SiC) switches and diodes, the power device gate-drive circuitry was implemented using low-temperature silicon (Si) logic circuits and passive components. Consequently, the gate-drive circuitry had to be located remotely from the high-temperature power board. To truly benefit from the advantages of high-temperature SiC power devices, high-temperature gate drive circuitry needs to be implemented. There are several radiation-hardened Si IC technologies that have been developed which can be optimized for high-temperature operation as a near term solution; with the ultimate solution being the implementation of SiC high-temperature CMOS. Also, there have been encouraging reports on low to moderate valued high-temperature capacitors and inductors that could be used to implement gate drive circuitry that will operate at a case temperature of 150 C. These high-temperature passive components are required for the short-and long-term solution.

PHASE I: Develop a feasibility concept utilizing high-temperature silicon-based logic components that are required to implement a controller board that provides the appropriate signals for pulse-width modulation (PWM) control of a DC-AC motor inverter with the ability to change the signal pulse shapes, frequency, duty cycle and dead time between pulses.

PHASE II: Initial Milestone -- Demonstrate a PWM controller board for a three-phase DC-AC motor inverter using the logic circuitry that was designed under the Phase I task and demonstrate the ability to operate at a heat sink temperature of 150C. Fabricate this controller board such that the passive components (resistors, capacitors, inductors) are not located on the same heat sink as the high-temperature logic circuitry. Demonstrate that the logic components can operate at a heat sink temperature of 150C and control a three-phase AC induction motor in the 5-10 hp range. Mid-term Milestone -- identify and obtain commercially available materials/components and demonstrate that the passive components required for the PWM controller can be implemented that will operate at a heat sink temperature of 150C. Final Milestone - Implement a full-up prototype PWM controller board that operates at a heat sink temperature of 150C and controls a three-phase AC motor (5-10 hp).

PHASE III DUAL-USE COMMERCIALIZATION: SiC devices are beginning to become available on the commercial market: 600 V 10 A diodes now, 1000 V 20 A diodes by the end of this year, and 1000 V 10 A Power MOSFETs by the beginning of 2003. Within three years it is anticipated that SiC switches will be available to fabricate power modules for many power conversion/control applications to include both industrial and military motor drive, power supply and power distribution applications. Conservative estimates have been given which suggest that the high-temperature power electronics business could have a $1B market share by 2007. The high-temperature control circuitry developed under this SBIR would enable and be a significant part of this market share.

REFERENCES:

1) Honeywell currently has a family (HTMOS) of ICs (including programmable gate arrays) that operate at 225C (HTMOS components in down hole logging tools have proven reliable up to 300 degrees Centigrade.) http://www.ssec.honeywell.com/hightemp/tech_paper.html

2) Allied Bendix had a high temperature SOI process for 225C using tungsten metalization. O'Connor-JM; Tsang-JC; McKitterick-JB "225 C high temperature silicon-on-insulator (SOI) ASICs for harsh environments," IWIPP Proceedings. IEEE International Workshop on Integrated Power Packaging (Cat. No.98EX203). IEEE, New York, NY, USA; 1998; ix+83 pp. p.2-5. PY: 1998

KEYWORDS: High-temperature logic components, high-temperature passive components, high-temperature motor drives, silicon carbide switches, SOI CMOS, SiC CMOS.

OSD02-EP04 **TITLE:** Phase-Change Cooling for Operational (Weapons) Environments

DoD Critical Technology: Power

MAIL PROPOSAL TO: Air Force Research Laboratory
Propulsion Directorate
ATTN: Laureen Regazzi, AFRL/PROB
1950 Fifth Street
Wright-Patterson AFB, OH 45433-7251 Phone: 937-255-1465

OBJECTIVE: Develop robust two-phase cooling technologies that will dissipate high heat fluxes and transport high heat loads for electric weapon platforms in realistic operational environments.

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 500-1000Watt/cm2. Subsequent system integration of a proposed thermal management concept, into the weapon platform, will require thermal transport from the high heat flux source to a heat rejection and/or energy storage device capable of greater than 100kW of heat during the operational duty cycle. 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 harsh operational environment upon deployment. Such weapon concepts may be ground, sea, and air based platforms operating in harsh environments, with limited rejection media available to use as a reliable heat sink. Examples of harsh environments may include shock and vibration, dusty ambient conditions, ambient temperatures ranging from -40oC to 65oC, and steady state and transient acceleration induced forces typical of high performance aircraft. The development of robust two phase thermal management concepts that will operate in a harsh environment typifying operational environments is required for extended operation of future electric weapon concepts.

PHASE I: Goals for Phase I should include a feasibility demonstration (e.g. concept analysis and subscale experiment) of the proposed two phase cooling concept, address integration issues, and provide sufficient analysis to demonstrate system level payoffs.

PHASE II: Goals for Phase II should include sufficient demonstration of the proposed two phase cooling concept to show integration viability into a weapon platform.

PHASE III DUAL-USE COMMERCIALIZATION: The development, demonstration, and integration of robust two phase cooling technologies into electric weapon platforms represents numerous technical challenges requiring innovative solutions which in turn can be directly applied in the military and private sectors. Examples of potential military and commercial applications may include but not be limited to cooling power conditioning electronics.

REFERENCES:

1) Huddle J., L. Chow, et al, 2000, "Advantages of Spray Cooling for a Diode Laser Module", SAE Power System Conference, October 31-November 2, 2000, San Diego, CA.

2) Sumida D., A. Betin, H. Bruesselbach, R. Byren, S. Matthews, R. Reeder, and M. Mangir, 1999, "Diode-pumped Yb:YAG Catches Up With Nd:YAG," Laser Focus World, pp. 63-70, June 1999.

3) Benford, J., 1995, "Making HPM practical", Conference: International Conference on Plasma Science, 5-8 June 1995, Madison, WI, USA.

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

OSD02-EP05 **TITLE:** Thermophotovoltaic Power Sources

DoD Critical Technology: Power Generation

MAIL PROPOSAL TO: US Army Research Laboratory
ATTN: AMSRL-DP-T (Dean Hudson)
2800 Powder Mill Road
Adelphi, Maryland 20783-1197 Phone: 301-394-4808

OBJECTIVE: To design, develop and demonstrate the feasibility of a man portable, low cost, high performance thermophotovoltaic (TPV) power source capable of producing 500 Watts (scalable to 1500 W) of electric power at 28 VDC. The unit shall be a stand-alone unit capable of starting and operating on military standard JP-8 fuel and of maintaining maximum power output for up to 8 hours without refueling. The unit shall provide rated continuous power at 500 W within a temperature range from - 32 ^{o}C (- 25 ^{o}F) to + 52 ^{o}C (+125 ^{o}F) at any possible relative humidity within this range. The desired power source shall be a signature suppressed, lightweight, reliable power source that is ruggedized for and compatible with installation and operation in military scout vehicles and vehicle-mounted command & control shelters of Future Combat Systems (FCS) and the Objective Force. It shall demonstrate a fuel to electric power output efficiency higher than 10 %, and a noise signature of 65 dBA or less at seven (7) meters. The system shall have a low probability of detection via thermal means and include concepts for operation in closed space environments.

The resulting power source shall meet the emerging power requirements for Silent Watch missions and the power requirements for command and control elements within the shelter/vehicle for the Objective Force.

Additional development interests for TPV include applications for direct energy conversion over a broad temperature range of 300 - 600 ^{o}C (or 572 ^{o}F – 1112 ^{o}F). This requires efficiencies of higher magnitude, on the order of 20% or greater.

DESCRIPTION: The military's vision is to develop lightweight Silent Watch Capabilities for its Future Combat Systems (FCS), Objective Force, and Special Operations Forces. To do this, requires quiet reliable power sources to execute critical capabilities within the C4ISR requirements such as communication, computers, surveillance, and reconnaissance. Quiet, compact, lightweight power will be the linchpin to the success of all Silent Watch applications of FCS and Objective Force. Recent breakthroughs in TPV technology have advanced the state-of-the-art substantially so that technical performance is now demonstrated and paths to performance enhancement are identifiable. What is needed now is to further enhance TPV system performance while emphasizing manufacturability and reliability as well as lowering system cost.

The SBIR effort will focus on the design and development of a quiet, lightweight, 28 VDC power source based on TPV Technology. The TPV unit shall be capable of operating on JP-8 fuel and of producing 500 W (scalable to 1500 W) of continuous power at 28 VDC in all military environments. It shall provide the power required for the operation of equipment (LCU computers, SINCGARS and Spitfire Radios, GPS, force protection systems, etc.) found mounted on / within scout vehicles such as HMMWVs, FISTV, M1068 Track Vehicles or the M2A3 Bradley Main Battle Tank. ***The weight of the TPV system shall be less than 75 pounds.***

PHASE I: The contractor shall develop a feasibility concept to include:

Identify the components of the 500 Watt (scalable to 1500 W) TPV system. Selected components shall be lightweight, compact, quiet and capable of surviving high shock and vibration that vehicle systems would experience on the battlefield, air, and marine environments.

Identify technology advancements needed to reduce parasitic losses and increase spectral control, etc. in order to achieve a peak system efficiency higher than 10 %. Identify the components (filters, emitters, TPV devices) that will be advanced / developed to achieve the desired system efficiency.

> *NOTE: The components selected and technology advancements identified shall also enable the unit to provide rated continuous power of 500 W within a temperature range from - 32 ^{o}C (- 25 ^{o}F) to + 52 ^{o}C (+125 ^{o}F) at any possible relative humidity within this range with no failures.*

Throughout the aforementioned identification process, emphasis shall be on component enhancements that simultaneously improve system performance and manufacturability as well as lower system cost. This analysis shall include discussions as to how each approach will lend itself toward reducing production costs.

The design discussions shall address thermal management issues from a system life, thermal cycling, infrared, and variable burn perspective.

Cost is important and must be reasonable. Safety is also important. Consideration should be given to the field scenario, where: a) power demand can vary widely from approximately 500 W to 1.5 kW, b) a cold start up capability and a short start-up time is required, and c) systems are subjected to rough handling and vibration.

PHASE II: Using the results of Phase I, the contractor shall conduct a detailed design and shall develop and fabricate a prototype proof of concept 500 Watt TPV power generation system that starts and operates on logistic fuels (JP-8). Results of the Phase I review of thermal management issues for a system approach shall also be integrated into the design and applied to the proof of concept unit.

The resulting proof of concept shall be tested by the contractor to ensure that it can *provide rated continuous power of 500 W within a temperature range from - 32 ^{o}C (- 25 ^{o}F) to + 52 ^{o}C (+125 ^{o}F) at any possible relative humidity within this range with no failures.* Fuel consumption, noise level, exhaust temperature, thermal cycling, infrared signatures, start-up time (including cold start), and quality of electrical output under changing load of the TPV configuration shall be determined.

The resulting test data shall be used to demonstrate the experimental feasibility of those enhancement technologies identified in Phase I that were to improve system performance and manufacturability and lower system cost.

The contractor shall explore system approaches, which improve fuel efficiencies to higher magnitudes, greater than 20%, and concepts, which enable the system to operate in closed space environments.

PHASE III DUAL-USE COMMERCIALIZATION: Potential commercial applications for very quiet generators that consume liquid fuel, for either primary or backup power, are automobiles, homes, emergency mobile hospitals, temporary field police stations, refrigerated semi-trailers and vans, recreational vehicles, boats, rural areas, and developing nations. The TPV system affords many advantages for Military Applications. There are no moving parts in a TPV unit; hence, reliability would be higher and noise signature would be lower. Projected fuel consumption, fuel delivery costs, maintenance costs and supply logistics costs appear to be lower with use of a TPV system.

REFERENCES:
Timothy Coutts, John Benner, and Carole Allman, editors, Proceedings of 4th NREL Conference on Thermophotovoltaic Generation of Electricity, Denver, CO, American Institute of Physics (1999).

KEYWORDS: Thermophotovoltaics (TPV); power generation, Silent Watch, and tactical shelters

OSD02-EP06 **TITLE:** Nanostructured Electrodes and Electrolytes for High Energy and Power Density Rechargeable Li and Li-Ion Batteries

DoD Critical Technology: Power Sources

MAIL PROPOSAL TO: Office of Naval Research
ATTN: Mr. Steven Jaeger, ONR Code 333,
BCT-1 (Room 507-10)
800 North Quincy Street
Arlington, VA 22217-5660 Phone: 703-696-5354

OBJECTIVE: Develop high energy density rechargeable batteries that take advantage of the improved performance of electrodes and electrolytes based on nanostructured materials.

DESCRIPTION: 21st Century military equipment will require more power dense and energy dense power sources to accommodate complex, integrated capabilities (i.e., propulsion, sensors, and remote information relay) on a single platform for manned and unmanned vehicles and for numerous man-portable applications. Low thermal and noise signatures to avoid detection, low weight and volume to reduce fielded size, safety, and cost will continue to be mission-critical aspects for these power sources. It is anticipated that the next generation of high energy rechargeable batteries will incorporate such features as nanostructured electrode materials and solid-state electrolytes in order to meet future high power and energy density requirements for a variety of platforms. Nanoscale active electrode materials have demonstrated significant energy density and rate improvements by virtue of the small active particle size. Nanostructured polymer electrolytes have shown improved lithium tranference numbers and structural stability, with the added benefit of safety due to avoidance of flammable liquid organic electrolytes.

PHASE I: Rechargeable nanostructured lithium-polymer batteries that meet mission target goals for the next generation of high energy density and high pulse power applications need to be developed. High energy density applications will require 400 Wh/kg with > 100 cycles over a wide temperature range (-20 to +90 C). High pulse power applications will require > 2 KW/kg power bursts for over 1 second with a nominal energy density > 100 Wh/kg, as well as good charge retention and rapid recharge capability from -20 to +90 C. Areas of interest include (1) nanostructured active electrode (anode and cathode) materials capable of meeting the high energy density or pulse power goals in a practical battery, (2) processing of high energy density electrodes of nanostructured active materials that retain the energy density, rate capability, and cycling stability of the active material, and (3) nanostructured polymer electrolytes that exhibit lithium ion transport on the order of tens of mS/cm to support the energy density, rate, cycling, and temperature goals. Phase I will develop a feasibility concept of new nanostructured materials or processed materials to meet the desired performance goals.

PHASE II: A packaged prototype battery that incorporates the nanostructured electrodes and polymer electrolytes identified in Phase I should be developed. The packaging should enable ease of handling for the end user (i.e., at least pouch or coin cell level or other appropriately packaged prototype). Performance at the high energy density or pulse power goals stated above should be demonstrated.

PHASE III DUAL-USE COMMERCIALIZATION: It is anticipated that lithium-polymer batteries developed under this program will provide the high energy and power densities required for a variety of military applications, and will do so in a more lightweight, compact form than is currently available. These enhancements will extend mission capabilities and duration and will improve safety. The continued trend towards more capabilities in commercial portable electronic products (notebook computers, palm pilots, etc.) that rely on lithium battery technologies to supply adequate energy in a small weight and volume indicates that further improvements in energy density and size reduction would rapidly transition to the commercial market. The commercial electronics battery market currently produces millions of lithium-ion batteries per month.

REFERENCES:

1) Scrosati, F. Croce, S. Panero, "Progress in lithium polymer battery R&D," J. Power Sources 100 (2001) 93-100.
2) J.-M. Tarascon and M. Armand, "Issues and challenges facing rechargeable lithium batteries," Nature 414 (2001) 359-367.

KEYWORDS: batteries, power sources, nanomaterials, cathode, anode, solid polymer electrolyte, lithium-polymer battery

OSD02-EP07 **TITLE:** High Efficiency Fuel Cell Reformer for Logistics Fuels

DoD Critical Technology: Power Sources

MAIL PROPOSAL TO: Office of Naval Research
ATTN: Mr. Steven Jaeger, ONR Code 333,
BCT-1 (Room 507-10)
800 North Quincy Street
Arlington, VA 22217-5660 Phone: 703-696-5354

OBJECTIVE: Develop innovative concepts and technologies to achieve high efficiency logistic fuel reformer technologies for fuel cell use.

DESCRIPTION: The military needs compact and efficient fuel cell reformers capable of processing logistic fuels such as JP-8, and diesel fuels, to enable the use of silent and efficient fuel cell technology for a wide range of mobile electric power plants and Auxiliary Power Source (APU) application. Future battle commanders will require an array of electric power generators that are silent, efficient, have low thermal signature, and can meet anticipated future environmental standards. Recent developments by industry and Government have yielded considerable progress establishing fuel processing for hydrocarbon fuels, including reforming catalysts that are sulfur tolerant. However, fuel processors are still much to complex for the compact, lightweight systems needed in military applications. To achieve the desired logistic fuel reformers for military applications innovative fuel processing technologies are sought including, but not limited to, the following: (1) thermally and chemically integrate structures that minimize the need for heat exchangers and increase reaction rates of the reforming processes (e.g., microchannel reformers); (2) hydrogen selective or catalytic membranes that remove hydrogen directly from the reformer or water gas shift (WGS) reactors to produce a hydrogen-rich fuel cell feed; (3) sulfur-tolerant high-space velocity water gas shift (WGS) catalysts; and (4) innovative approaches for removing sulfur from logistics fuels or from the reformer gas stream.

PHASE I: Develop a feasibility concept utilizing the proposed technology to enhance reforming of logistic fuels.

PHASE II: Demonstrate the viability of the proposed technology to enhance reforming of logistic fuels at the laboratory bench scale. Perform preliminary engineering studies to show how the proposed technology would scale to power levels up to 500kW and be integrated into a complete logistics fuel reformer. Design, build, and demonstrate the proposed reformer component at a size compatible with a 5 to 500 kW overall fuel processing system. The sizing will be dependent on the technology proposed. For example, reactive membranes may be sized for 5 kW systems since the cost of such approaches may preclude production of large units under this call, while sulfur-tolerant catalysts should be incorporated in a reactor at the 500 kW level for eventual integration into a complete fuel processing unit.

PHASE III DUAL-USE COMMERCIALIZATION: Fuel cell power plants with efficient and compact reformers promise significant gains in power density compared to reformer processes now existing. The technology should be applicable over wide range power applications. It will help open up markets for fuel cell power sources in transportation, portable communications, remote stations, APU's and residential applications.

REFERENCES:
"Marine Applications of Fuel Cells - A Multi-Agency Research Program," Allen, S., Ashey, E., Gore, D., Woerner J., and Cervi, M., *Naval Engineers Journal*, 110 (1): 93-106 Jan 1998.
"Applications of Catalytic Inorganic Membrane Reactors to Refinery Products," Armor, J. N.
Journal of Membrane Science, 147 (2): 217-233 Sep 2 1998.

KEYWORDS: fuel cells, fuel processing, reformer, water gas shift, membranes, membrane reactors, hydrogen, catalysts

OSD02-EP08 **TITLE:** Small Scale Fuel Cells for Ground Personnel

DoD Critical Technology: Power

MAIL PROPOSAL TO: US Army Research Laboratory
ATTN: AMSRL-DP-T (Dean Hudson)
2800 Powder Mill Road
Adelphi, Maryland 20783-1197 Phone: 301-394-4808

OBJECTIVE: Develop improved compact fuel cell power systems.

DESCRIPTION: The military has need for compact and lightweight person-portable power sources for a variety of applications including communication, computation, and sensors. A typical power level requirement is 20 W; power sources of that power level can normally be scaled up or down a factor of 2-3 to cover many of the DoD needs. Hydrogen-air and direct-methanol polymer electrolyte membrane fuel cells (PEM FCs) are candidates to fill these needs, but challenges remain to be addressed before low-cost, reliable, and long-lived FCs are fielded by the services. Hydrogen supply is problematical and high-energy density storage and delivery hydrogen systems are required (e.g., 1 kWh/kg). Thermal processing of hydrocarbon fuels is a route to hydrogen, and microchemical-based systems are candidates to perform the chemistry, but materials (e.g., catalysts) and engineering (e.g., thermal integration) issues remain to be addressed. The membrane electrode assembly (MEA) in the FC itself is a complex multifunction structure of electrocatalyst, ionomer, electronic conductor, and gas channels and remains to be optimized by, for example, materials selection and directed assembly of nano- and meso-scale architectures.

NOTE: All of the materials, processes, components, etc. listed below must be designed for safety, for very light weight, very low physical volume, high efficiency (to minimize parasitic power losses), ruggedness, and ease of manufacturing (to reduce cost).
Specific areas of interest:
Area 1: *Auxiliary components for balance-of-plant (BOP)* The list below contains examples of items desired but is not intended to be complete: Pumps, high-pressure (10-100 kPa) blowers, low-pressure (<5 kPa) fans, heat exchangers for cooling the system or for condensing exhaust water for recycling to fuel processors, and recuperators.
Area 2: *Technology for handling fuels and processing fuels to meet fuel cell requirements.* Compact hydrogen generation and storage. Reformers for fuels of significant (>5000 Wh/kg) energy density. Hydrogen purification.
Area 3: *Materials and processes for electrochemical energy conversion.* Examples include electrocatalysts, catalyst supports, fuel cell electrolytes, system designs to enable use of concentrated methanol fuel, direct oxidation of potential fuels such as ethylene glycol. Examples of approaches might be a new way of forming structured materials on various template molecules or use of macromolecular synthesis to produce materials which could lead to improved MEAs by enhancing transport of fuel or oxidants to catalyst particles in the MEA.

Note 1: It is required that each proposal address a single topic area; the proposal shall identify the specific area in the first sentence of the abstract.

Note 2: Fuel cell system components which are not likely to be suitable for systems in the 20 W power range are not of interest.

PHASE I: Through a feasibility study, supported by in-house generated experimental data, literature results, and/or appropriate analytical modeling, demonstrate that the proposed research addresses needs identified above for an improved FC power system. Identify safety concerns associated with proposed concept.

PHASE II: Design and construct the requisite breadboard-level apparatus to assess quantitatively the efficacy of the proposed research in advancing state-of-art FC power systems. Address the safety concerns identified in Phase I.

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

REFERENCES:

1) L. Carrette, K.A. Friedrich, and U. Stimming, "Fuel Cells---Fundamentals and Applications," *Fuel Cells*, **1** (2001) 5-39.
2) S. Arico, S. Srinivasan , and V. Antonucci, "DMFCs: From Fundamental Aspects to Technology Development," *Fuel Cells*, **1** (2001) 133-161.

KEYWORDS: Fuel cells, fuel processors, polymer electrolyte membrane, membrane electrode assembly, electrocatalyst, hydrogen

OSD02-EP09 **TITLE:** Thermionic Power Source Technology.

DoD Critical Technology: Electrical Power, Thermal Energy Conversion

MAIL PROPOSAL TO:

Air Force Research Laboratory
Propulsion Directorate
ATTN: Laureen Regazzi, AFRL/PROB
1950 Fifth Street
Wright-Patterson AFB, OH 45433-7251 Phone: 937-255-1465

OBJECTIVE: To develop thermionic energy conversion technology that will enable high energy density thermionic electrical power sources within 10-15 years for space, aircraft, ground and naval systems. There is need to generate electrical power from high temperature heat sources on mobile vehicles or remote installations that would otherwise go untapped. The heat source temperature specifications depend on application, ranging from below 1000K to 2000K. Development is required to produce advanced thermionic emitters for applications involving lower temperature operation in order to provide >15% device efficiency at temperatures at or below 1000K. For low temperature applications, the goals would be to enhance thermal coupling between the source and emitter or provide new materials with properties (i.e. low work function) suitable for conversion at low temperature. For applications involving emitter temperatures above 1800K, advanced converter materials and designs need to be developed to insure reliability and lifetime. High temperature converter response to repeated thermal cycling and sustained operation above 1800K requires investigation. Multi-cell thermionic converter design and configuration require further study to determine how to maximize the system power density. A general power density goal (thermionic converter only) is 100 W/kg, but this may vary depending on application.

DESCRIPTION: Thermionic energy conversion has the potential to satisfy many future power needs through static conversion of thermal energy. A thermionic power source provides advantage through a compact and survivable system with no moving mechanical parts. Space applications include solar energy conversion for orbital spacecraft and nuclear energy conversion for deep space. Terrestrial applications include direct conversion of a primary (fossil fuel or nuclear) heat source or conversion of secondary heat from a primary propulsion or generator system. Development of a thermionic power source requires development of various components, including the heat source, the interface between heat source and thermionic energy converter, the thermionic converter cell, the heat rejection system, and the electrical power control system.

PHASE I: Thermionic Performance Enhancement: A detailed study on an advancement in thermionic power system technology will be conducted in concert with experiments to identify novel approaches and designs to thermionic devices and materials. The phase I activities should develop a feasibility concept of new designs, materials, components, and/or system architecture to improve performance of the thermionic converter in the temperature range of interest. Focus on improvement of component technology will be crucial. System studies which consider heat transfer from source to emitter as well as coupling output to load are encouraged.

PHASE II: Component Fabrication/Testing: The phase II program will focus on implementation and demonstration of the various components designed in Phase I into a prototype with demonstrable performance improvements. Phase II should also consider potential lifetime issues of the device, potential for development into a easily manufactured system and issues associated with scale up and cost.

PHASE III DUAL-USE COMMERCIALIZATION: The demand for reliable remote power continues with increasing levels of power. As power requirements rise, conventional electrical power sources are pressed to fulfill the role of a survivable, high-power system. Both commercial and military space systems will benefit by the replacement of large photovoltaic arrays with low-mass, low volume, thermionic power systems. Military and commercial terrestrial power generation units could use the enhanced efficiency brought by a secondary thermionic power unit. It is anticipated that a successful development of thermionic power technology will benefit military and commercial organizations alike.

REFERENCES:

1) National Research Council, Committee on Thermionic Research and Technology, Tom Mahefkey et al., "Thermionics Quo Vadis?, An Assessment of the DTRA's Advanced Thermionics Research and Development Program", (2001) ISB 0-309-08282-X
2) T.R. Drake, "DoD's Advanced Thermionics Program: An Overview," Proceedings of the 33rd Intersociety Engineering Conference on Energy Conversion, American Nuclear Society (1998)
3) A.C. Marshall, "An Equation for Thermionic Currents in Vacuum Energy Conversion Diodes", Applied Physics Letters, v73, pp2971 (1998)
4) M.S. El-Genk, "A Critical Review of Space Nuclear Power and Propulsion 1984-1993", AIP Press, New York, (1994)

KEYWORDS: thermionic converters, electrical power, high temperature materials, low work function

Deputy Under Secretary of Defense Science And Technology Focus Area
Cognitive Readiness For Transformational Knowledge Systems

The Deputy Under Secretary of Defense for Science and Technology DUSD(S&T) established a science and technology (S&T) focus area in late 1999 to explore Cognitive Readiness research issues and unknowns. The Cognitive Readiness focus area provided a cross-component, multidisciplinary S&T framework to focus on the human dimension of joint warfighting capabilities. Subsequently, in late 2001, the Department established a new Transformation Initiative, Cognitive Readiness for Transformational Knowledge Systems—that subsumed and broadened the goals of Cognitive Readiness to include additional aspects of human readiness which includes knowledge systems. It includes the knowledge systems necessary for the human dimension of warfare to include personnel performance and training, personnel protection, cognitive and behavioral adaptability, mission planning and rehearsal, status reporting and predictive assessment, and human systems integration into warfighting.

The fundamental premise underlying *Cognitive Readiness for Transformational Knowledge Systems* is that *the human is the prime resource and key enabler in all warfighting systems*. U.S. forces must be manned, trained, and equipped to respond to an array of contingencies, including major theater war(s), small-unit operations, operations other than war (OOTW), overseas presence operations, homeland defense, as well as other missions to support the National Command Authorities. Indeed, *Joint Vision 2010* identified "readiness" as the foundation for enabling joint operational capabilities—readiness in terms of people, training, leader development, and first-rate equipment. *Joint Vision 2020* reinforces and extends this philosophy by emphasizing and encouraging human innovation as the key force multiplier of the future. *Cognitive Readiness for Transformational Knowledge Systems* focuses on supporting these aspects of the Vision.

The optimization and enhancement of human performance is challenged by many different factors, such as general health issues, mental and physical stress, cultural and societal influences, environmental stressors (e.g., heat, cold, altitude, and information overload), adequate education and training. Currently, there are two "core" Department of Defense program areas organized to address Cognitive Readiness for Transformational Knowledge Systems issues, the Biomedical and Human Systems programs with subcomponents dealing in health, psychology, sociology, personnel and training, and human factors engineering issues.

The following fifteen topics were selected for this initiative:

- OSD02-CR01 Warrior Readiness for Coalition and Collaborative Teams, Army Research Institute
- OSD02-CR02 Warrior Cognitive Skills Assessment Battery, Army Research Institute
- OSD02-CR03 Dismounted Infantry Situational Awareness Assessment in Virtual Simulations, Army Research Institute
- OSD02-CR04 Automated Analysis of Communications from Synthetic Environment Exercises, Army Research Institute
- OSD02-CR05 A Load Expert System, Incorporating an Advanced Biodynamics Model into Load Cost Functions and Development of Load Utility Functions, Natick Soldier Center
- OSD02-CR06 Integration of Behavior Moderators into Cognitive Performance Models for Assessing Cognitive Readiness, Natick Soldier Center in collaboration with Army Medical Research MRMC
- OSD02-CR07 Measuring Multi-tasking Ability, Office of Naval Research
- OSD02-CR08 Information Delivery Configuration for Augmented Warrior Readiness, Air Force Rome Laboratory
- OSD02-CR09 Real-time Simulation Network and Human Performance Measurement Device for Distributed Mission Training (DMT), Air Force Research Laboratory
- OSD02-CR10 Accommodation Engineering and Decision Aide (AEDA), Air Force Research Laboratory
- OSD02-CR11 Identifying and Capturing the Cognitive Demands Imposed by New Systems, Air Force Research Laboratory

- OSD02-CR12 Application of Culturally Specific Aspects of Human Behavior to Adversarial Decision-Making, Air Force Research Laboratory in collaboration with Natick Soldier Center

- OSD02-CR13 Design of Sharable Content Objects with Return on Investment, Naval Air Warfare Center

- OSD02-CR14 Multi-Modal Visualizations for Virtual Environment Training Systems, Naval Air Warfare Center

- OSD02-CR15 Web-based Game Design Advisor, Naval Air Warfare Center in collaboration with Army Research Institute

The topics are on the following pages.

OSD02-CR01 **TITLE**: Warrior Readiness for Coalition and Collaborative Teams

DoD Technology Area: Human Systems R&D

FEDEX PROPOSAL TO: Dr. Angela Karrasch
U.S. Army Research Institute
Leader Development Research Unit
851 McClellan Avenue
Ft. Leavenworth, KS 66027-1360

OBJECTIVE: Determine the impact of particular skills, knowledge and attributes on our warfighters' abilities to successfully build, develop, and assess capabilities of multinational teams for military operations other than war.

DESCRIPTION: The United States' increased involvement in military operations other than war and the recent focus on counter-terrorism have highlighted the importance of coalitions, multinational collaboration, and civil-military coordination. One of the first tasks a leader engages in, upon taking command, is to assess the capability and readiness of his/her troops. This is not an easy task, but it is critical to developing and building a high performing team. Assessing team capability becomes much more challenging when one is faced with language barriers, cultural biases, cultural differences, varying levels of capability and a lack of shared experiences. The current state of the research on teams does not sufficiently address how a leader can ameliorate the effects of cross-cultural barriers in international teams. How does a leader most rapidly build cohesion, agility, and efficient performance of a multinational team? What does a leader need to be, know, and do to successfully build teams that involve many national forces and civil organizations?

PHASE I. The Phase I effort would involve determining the skills, knowledge and abilities (SKAs) that are critical for building and developing teams involved in operations such as humanitarian relief, peacemaking operations or other stability and support operations. Additionally, recommendations for training to develop the particular SKAs with the highest potential for increasing a warriors' readiness to lead multinational teams should be developed.

PHASE II. The Phase II effort would involve developing and evaluating the recommended training. Additionally, an assessment tool that provides detailed feedback on the warrior's readiness with regard to the SKAs defined as essential for assessing, building, and developing multinational teams would be developed.

PHASE III. DUAL USE COMMERCIALIZATION: The research efforts describe above would lead to a greater understanding, training and evaluation concepts and an assessment tool which private and public organizations would be interested in obtaining. Commercial industrial customers realize that international business depends on their ability to grow and develop senior leaders capable of leading diverse teams.

REFERENCES:

1) Army Leadership. FM 22-100, Washington, DC: Headquarters, Department of the Army.
2) LaJoie, A. and Sterling, B. (1999). A Review and Annotated Bibliography of the Literature Pertaining to Team and Small Group Performance (1989 to 1999). Research Product No. 2000-01. U.S. Army Research Institute for the Behavioral and Social Sciences: Alexandria, VA.
3) Wentz, Larry (Ed.) (1997). Lessons From Bosnia: The IFOR Experience. Institute for National Strategic Studies, Washington, D.C.

OSD02-CR02 **TITLE**: Warrior Cognitive Skills Assessment Battery

DoD Technology Area: Human Systems

FEDEX PROPOSAL TO: Robert J. Pleban
ARI FIELD UNIT-FORT BENNING
75B, MCVEIGH HALL
ANDERSON STREET & WOLD AVE
FORT BENNING, GA 31905-6001

OBJECTIVE: Develop a cognitive skills assessment battery for evaluating small unit leader adaptive thinking and decision-making capabilities.

DESCRIPTION: Future warfare will put enormous demands on the warrior leader's information processing and decision-making skills. Soldiers will deploy almost anywhere in the world on very short notice. Increasingly, they will fight in urban and restricted terrains. Rapidly changing rules of engagement and compressed timetables will be the norm. Units must be capable of defeating mixes of conventional, unconventional, or non-state enemy forces and execute stability and support operations. New technological capabilities will provide small unit leaders with a greater variety of tools than ever before. Leaders must develop competence and confidence in using the new tools under stress, understand how all the tools interact, and be able to continue the mission when the tools fail. These new technologies will translate into increased operational effectiveness only if leaders at all echelons know how to make good use of the information provided by these systems. Leaders must be trained to make rapid, sound decisions based on this information that have critical implications for mission success. A cognitive skills assessment battery is needed to identify specific strengths and weaknesses in leader decision-making/adaptive thinking skills. Developing the appropriate warrior leader skills requires a comprehensive methodology and a set of metrics to accurately assess training progress and provide the necessary feedback to enhance leader performance.

PHASE I: Phase I shall address the key decision and information requirements facing the small unit leader (e.g., platoon and squad). A front-end analysis shall be conducted to determine small unit leader decisions and decision dynamics and identify the types of cognitive skills to assess. Potential means for assessing these small unit leader skills shall be identified. Specific environments will be analyzed for their suitability for conducting decision-making/adaptive thinking skills assessments. The strengths and weaknesses of each environment shall be addressed. The proposed solutions for creating a comprehensive, flexible cognitive skills assessment battery shall be documented in a Phase I report. The report shall include findings from the front-end analysis that identifies the key decision and information requirements confronting small unit leaders and provides a full description of proposed measures of performance. The report shall also address the appropriateness of specific measures for assessing leader skills in different environments (e.g., virtual, classroom, field) and provide recommendations for applying the findings to warrior readiness training. In addition, a comprehensive plan shall be developed for assessing the reliability and validity of each proposed performance measure.

PHASE II: In Phase II, a cognitive skills assessment battery shall be developed that can be tailored for specific environments (e.g., virtual, game, field setting) and leader echelons. An assessment plan shall be developed for review and approval. Performance measures appropriate for each environment (and specific cognitive skill) shall also be developed, tested, and revised as necessary through an iterative process. Reliabilities and validities for each measure shall be documented. An evaluation of the cognitive skills assessment battery shall be conducted. A report describing these findings shall be produced.

PHASE III DUAL USE APPLICATIONS: This phase includes tailoring the approaches and assessment procedures to other military and commercial markets. There is a potential commercial market for a cognitive skills assessment capability. This capability could be used for identifying and training high performing individuals for situations demanding rapid processing of varied information from multiple sources where decision accuracy and adaptable thinking skills under stress and uncertainty are critical. Examples of such situations include police actions, emergency medical treatments, and fire fighting.

REFERENCES:

1) Klein, G. (1997). An overview of naturalistic decision-making applications. In C. E. Zsambok and G. Klein (Eds.), Naturalistic Decision Making (pp. 49-59). Mahwah, NJ: Lawrence Erlbaum.

2) Pleban, R. J., Eakin, D. E., Salter, M. S., & Matthews, M. D. (2001). Training and assessment of decision-making skills in virtual environments (Research Report No. 1767). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (ADA389677)

3) Strater, L. D., Endsley, M. R., Pleban, R. J., & Matthews, M. D. (2001). Measures of platoon leader situation awareness in virtual decision-making exercises (Research Report No. 1770). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (ADA 390238)

OSD02-CR03 **TITLE**: Dismounted Infantry Situational Awareness Assessment in Virtual Simulations

DoD TECHNOLOGY AREA: Human Systems R&D

FEDEX PROPOSAL TO: Donald R. Lampton
SIMULATOR SYSTEMS RESEARCH UNIT
ATTN: TAPC-ARI-IF
de FLOREZ BLDG, RM 2011
12350 RESEARCH PARKWAY
ORLANDO, FL 32826-3276

OBJECTIVE: Develop tools and techniques to assess Warrior Readiness through measurement of team and team leader situational awareness during Infantry fire team, squad, and platoon level exercises conducted in Virtual Environments and the After Action Reviews (AARs) which follow those exercises.

DESCRIPTION: Dismounted infantry simulations using Immersive Virtual Environment (VE) technologies are being developed to support small unit (fire team, squad, and platoon) training; mission rehearsal; and exploration and evaluation of potential changes in doctrine, organizations, equipment, and soldier characteristics.
Distributed Interactive Simulation (DIS) networks enable After Action Review replays of VE exercises such that the exercises are precisely recreated and can be viewed from any angle. Thus, AARs for VE exercises are very effective at addressing the key issues of "what" happened during an exercise. The ability to precisely determine and display what happened is a very useful, but in no way complete, tool for addressing the other key issues of "why" events happened and "how to improve" subsequent team and team leader performance. The issues of "why" and "how to improve" often involve the situational awareness (SA) of the team and team leader during an exercise. Techniques such as Situation Awareness Global Assessment Technique (SAGAT) assess SA during exercises. Although these techniques are very useful for many research applications, they temporally disrupt the continuity of exercises. Therefore, from training and performance measurement perspectives it would be valuable to be able to use a two-pronged approach to SA assessment: (1) capture some measures of SA during the exercise using unobtrusive measure such as eye tracking, electrophysiological measures, and capture and analysis of digital and voice communications: and (2) assess SA during the AAR, after completion of an uninterrupted VE exercise. SA debriefing techniques that would preclude temporal continuity of an exercise would therefore be addressed during the AAR, where they would be less disruptive. The content, format, and rapidity of SA assessment should be tailored to two different uses: One, feedback for the team and trainees given before the conclusion of the AAR, and two, quantified detailed measures of SA to support training and simulation research.

PHASE I: Phase I activities should: identify existing relevant approaches to SA measurement of small dismounted Infantry units and leaders; examine the feasibility of applying those approaches in a manner transparent to trainees conducting mission exercises in VE; specify content and format of SA measurement reports for feedback to trainees, and to support training and simulation research; and integrate these finding into a blueprint for producing an SA measurement system that would function with a DIS- or HLA-compliant dismounted Infantry simulation such as the Synthetic Squad Environment at the Dismounted Space Battle Laboratory at Fort Benning, GA.

PHASE II: In Phase II, develop an integrated and comprehensive system for measuring SA in dismounted Infantry VE training exercises without breaking the temporal continuity of an exercise. The product should include: explicit guidelines for constructing and conducting scenarios conducive to deriving outcome measures of SA; SAGAT-like techniques and rating procedures adapted for use during the replay of the exercise; software and interfaces for generating SA measurement reports for feedback to trainees and to support training and simulation research; and a sample set of scenarios.

PHASE III DUAL-USE COMMERCIALIZATION: The proposed enhancements of After Action Review systems would have commercial value for training in a variety of areas, including security and homeland defense, medicine, industrial hazards containment, fire fighting, search and rescue, law enforcement, and aviation in addition to many DOD applications.

REFERENCES:

1) Ehrlich, J.A., Knerr, B.W., Lampton, D.R., & McDonald, D.P. (1997). Team situational Awareness training in virtual environments: potential capabilities and research issues. (ARI Technical Report 1069). Alexandria, VA: US Army Research Institute.

2) Endsley, M. R., & Garland, D. G. (Eds.). (2000). Situation awareness analysis and measurement. Mahwah, NJ: Lawrence Erlbaum.

3) Endsley, M. R., Holder, L. D., Leibrecht, B. C., Garland, D. C., Wampler, R. L., & Matthews, M. D. (2000). Modeling and measuring situation awareness in the infantry operational environment. (Research Report 1753). Alexandria, VA: US Army Research Institute.

4) Matthews, M. D., Pleban, R. J., Endsley, M. R., & Strater, L. G. (2000). Measures of infantry situation awareness for a virtual MOUT environment. In Proceedings of the Human Performance, Situation Awareness and Automation: User-Centered Design for the New Millennium. Savannah, GA: SA Technologies, Inc.

5) Strater, L. G., & Endsley, M. R. (2000). SAGAT: A situation awareness measurement tool for commercial airline pilots. In Proceedings of the Human Performance, Situation Awareness and Automation: User-Centered Design for the New Millennium. Savannah, GA: SA Technologies, Inc.

6) Strater, L. D., Endsley, M. R., Pleban, R. J., & Matthews, M. D. (2001). Measures of platoon leader situation awareness in virtual decision making exercises. (Research Report 1770). Alexandria, VA: US Army Research Institute.

KEYWORDS: After Action Review (AAR), Situational Awareness, Virtual environments, virtual simulations, training, training effectiveness

OSD02-CR04 **TITLE**: Automated Analysis of Communications from Synthetic Environment Exercises

DoD TECHNOLOGY AREA: Human Systems R&D

FEDEX PROPOSAL TO: Donald R. Lampton
SIMULATOR SYSTEMS RESEARCH UNIT
ATTN: TAPC-ARI-IF
de FLOREZ BLDG, RM 2011
12350 RESEARCH PARKWAY
ORLANDO, FL 32826-3276

OBJECTIVE: Develop a system to analyze voice and digital radio communications from synthetic environment exercises.

DESCRIPTION: Synthetic environment exercises play a critical role in military training; mission rehearsal; and exploration and evaluation of potential changes in doctrine, organizations, and equipment. The network of systems that underlie synthetic environment exercises is well suited for capturing, replaying, and making available for subsequent analysis detailed information about entity movements and the use and effects of weapons. However, in contrast to the very detailed reports and analyses that can be readily generated on exercise firing and movement, there are no systematic tools for analyzing and summarizing digital and voice communications data, or for linking the timing and content of the communication to other battlefield activities. The military is moving toward more and more digital forms of communication but has not abandoned radio communications as well.

Digital and voice communications are messages between nodes in tactical networks. Methods are needed to parse and understand the content of both written and verbal messages and relate that content to situations occurring within training exercises. Dimensions of interest include but are not limited to the following: quantity (number and duration of messages); source (commander, unit leader, or unit members); speed (how quickly are responses made?); format (are communications complete and in proper format?); content (relationship of the communication to the tactical situation).

The approach developed should take advantage of the structure inherent in military communications: use of call signs and specific report formats, such as a Situation Report (SITREP). The content, format, and rapidity of communications assessment should be tailored to two different uses: (1) feedback for the team and trainees given before the conclusion of the AAR; and (2) quantified detailed measures communications to support training and simulation research.

PHASE I: Phase I activities should: identify dimensions of interest of digital and verbal (radio) communications; identify existing relevant off-the-shelf voice recognition and text parsing technologies; describe how these technologies can be integrated with synthetic environment technologies within a data collection and After Action Review System; and integrate these findings into a blueprint for producing a communications analysis system that would function with an HLA-compliant tactical simulation.

PHASE II: In Phase II, the developer will integrate off-the-shelf recognition, parsing, data management, and After Action Review technologies identified in Phase I with simulation technologies into a prototype system capable of handling maneuver, firing and communication information for both feedback in training and research.

PHASE III DUAL-USE COMMERCIALIZATION: Development of a communications analysis system would have commercialization potential for training, training management, research, and real-time operations applications for DoD and other potential customers that utilize digital and verbal communications in their operations.

REFERENCES:

1) Brown, B.R., Anderson, L., Begley, I.J. II, & Meliza, L.L. (1999). Cognitive requirements for information operations training (Study Report 99-02). Alexandria, VA: US Army Research Institute. (ADA365483)

2) Brown, B.R., Wilkinson, S., Nordyke, J., Riede, D., & Huysson, S. (1996). Demonstrating the concept of an Automated Training Analysis and Feedback System (Technical Report 1043). Alexandria, VA: US Army Research Institute. (ADA328445)

3) Garner-Bonneau, D. (1999). Human factors and voice interactive systems. Boston: Kluwer Academic Publishers.

4) Klevans, R. L. (1997). Voice recognition. Boston: Artech House.

5) Morrison, J.E., & Meliza, L.L. (1999). Foundations of the After Action Review process. (Special Report 42). Alexandria, VA: US Army Research Institute. (ADA368651)

6) Roe, D.B. & Wilpon, J.G. (Eds.).(1994). Voice communication between humans and machines. Washington, D.C.: National Academy Press.

KEYWORDS: After Action Review (AAR), virtual environments, virtual simulations, training, training effectiveness, speech recognition,

OSD02-CR05 **TITLE:** A Load Expert System, Incorporating an Advanced Biodynamics Model into Load Cost Functions and Development of Load Utility Functions

DoD Technology Area: Human Systems

MAIL PROPOSAL TO: US Army Natick Soldier Center
ATTN: AMSSB-RSS-MA(N) (Thomas Gilroy)
Natick, MA 01760

OBJECTIVE: Develop a load expert system, relative to the individual combatant and small group that examines the costs and usefulness of a given load in accomplishing various tasks in a variety of mission scenarios.

DESCRIPTION: Load issues and the effects of load stressors have long been recognized as a key element of Warrior Readiness for dismounted combatants. From an operational and a research, development, and acquisition perspective, Warrior Systems proponents has have an on-going need to examine trade-offs between the burden and benefit of various items that comprise the soldier's load. This is the function of a Load Expert System. This system requires three principle components: load "cost" functions, load "utility" functions, and the optimization routines to explore the trade-offs between costs and utilities for a given mission scenario.

Currently, reasonably good functions exist to assess load cost in terms of metabolic workload associated with weight and encumbrance. Additional functions assessing the cost are desired. Research into the use of a neural oscillator based control scheme for integration into a physics-based predictive model of human locomotion and load carriage would support this goal. The US Army Natick Soldier Center (NSC) is currently supporting research into the creation of a physics-based, predictive, computer model of human locomotion and load carriage. This work is a major leap forward in being able to effectively model the human and is critical to the goal of having a modeling capability for the virtual prototyping of soldier equipment and predicting the effects of equipment on performance. However, there is no capability of the model to emulate the complex neural control that a human utilizes during locomotion or load carriage. To date, the models resulting from this research have not been combined with a detailed physics based predictive model for walking and load carriage because no such model has existed. The incorporation of a model of the neural oscillators required for human locomotion and posture control during load carriage with the current physics-based computer model would represent a major scientific and practical achievement. Since, the current model for locomotion is being compared against human data collected in the NSC Biomechanics Laboratory, the incorporation of a more biodynamically correct control model should result in improved agreement between the simulated and experimental results. In addition to predicting warrior performance and enhancing the design process for equipment, this tool would enhance our ability to predict fatigue.

Another key part of the Load Expert System is therefore the development of load utility functions and the incorporation of these functions with consideration of load costs. Such utility functions should provide a measure or measures of the usefulness of an individual combatant, or group load configuration, in accomplishing various mission objectives within different scenarios. Particularly desirable is a function or functions that specify a marginal utility for incremental additions of mission capability, whether it be greater quantities of consumable stores or increased functionality due to modified or new equipment. Measures of usefulness should take into account the uncertainties in a combat environment. Key inputs to the function include equipment capabilities, load material definition, the weight of the material, the material's distribution or configuration, the mission objective or goal, mission resource requirements, and the overall mission scenario.

PHASE I: Objectives of the Phase I research are to:

1) Researching models, the role of neural oscillators in human locomotion and creating a proof of concept model which will be incorporated into a planar model of human walking as the primary control mechanism.
2) Evaluate potential algorithmic methods and identify promising methods for developing load utility functions.
3) Select of one or two such methods for follow-on development.
4) Identify data requirements of the load utility function.
5) Develop a cross matrix between "utility" as measured by the function(s) chosen and specific mission objectives, tasks, and scenarios.
6) Identify the method of integration with a load cost function in order to develop load optimization routines.

7) Deliverables will include a detailed report of all findings including data, analyses, and evaluations from the Phase I effort.

PHASE II: The Phase II objectives include:

1) developing and incorporating a first generation model into a physics-based predictive model of human locomotion and load carriage. In addition, this phase will also include validation of this system against data from walking and load carriage experiments,
2) algorithm implementation and validation. The algorithm must provide at least one measure of load utility that is able to use the inputs identified during Phase I. This measure must be such that it can be integrated with a load cost function output in order to support load optimization routines. The algorithm developer is responsible for obtaining existing data that may be available for this effort. The developer is not expected to collect new data during Phase II.

PHASE III DUAL USE COMMERCIALIZATION POTENTIAL: The simulation tools developed under this SBIR topic would have broad applications to the Army in equipment design, virtual prototyping and prediction of soldier performance. In addition, the resulting biodynamic simulation model would be marketable in the areas of sports science and rehabilitation. The load utility functions also have potential use in the world of commercial military and/or adventure games where they can be integrated into decision aids for players during game set-up, in choosing how to equip simulated entities, and in the use of game scoring algorithms, reflecting on the "goodness" of player decisions.

REFERENCES:

1) Buckalew, L.W. "Soldier Performance as a Function of Stress and Load: A Review". Army Research Institute Final Report No. ARI-RR-1545, AD Number: ADA221530, January 1990.
2) Paas, F.G.; Adam, J.J. "Human information processing during physical exercise". Ergonomics 34(11):1385-97, 1991.
3) Patton, J.F. et al. "Physiological and perceptual responses to prolonged load carriage". USARIEM Technical Report #T11-90, February, 1990.
4) 4.Griffin, L, West, D.J. and West, B.J. "Random Stride Intervals with Memory." J. Biological Physics 26: 185-202 (2000).
5) Playter, R., Blank, W., Jewell, D., Cornelius, N., Pratt, J. and Obusek, J. "Validating a Physics-Based Simulatin of a Load Carriage Task", Paper presented at the SAE Conference (2000).
6) Golubitsky M, Stewart I, Buono P.L. and Collins J.J. "Symmetry in locomotor central pattern generators and animal gaits." Nature 401: 693-695 (1999).
7) Golubitsky M., Stewart I., Buono P-L and Collins J.J. "A modular network for legged locomotion." Physica D 115: 56-72 (1998).
8) Lauk M, Chow C.C., Pavlik A.E. and Collins JJ. "Human balance out of equilibrium: nonequilibrium statistical mechanics in posture control." Physical Review Letters 80: 413-416 (1998).

KEYWORDS: Simulation, Load Carriage, Load Utility, Load Cost, Load Optimization, Individual Combatant, Locomotion, Neural Oscillator

OSD02-CR06 **TITLE:** Integration of Behavior Moderators into Cognitive Performance Models for Assessing Cognitive Readiness

DoD Technology Area: 11. Human Systems

MAIL PROPOSAL TO: US Army Natick Soldier Center
ATTN: AMSSB-RSS-MA(N) (Tom Gilroy)
Natick, MA 01760-5019

OBJECTIVE: There are two distinct, but highly complimentary objectives.

1) The first objective is to develop a comprehensive model of behavior moderators present in combat environments and their effects on the individual combatant's ability to accomplish cognitive tasks in various mission scenarios. The behavior moderators considered should include fatigue, environmental stressors, equipment, and potential performance enhancers.

2) The second objective is to develop a full-spectrum model of cognitive functioning applicable to combat environments in which behavioral moderators attenuate or prevent cognitive deficits. The model should include a broad range of combat environmental stressors, occurring in various mission scenarios. The behavioral moderators should result in enhanced cognitive or behavioral performance. A variety of cognitive tasks should be considered.

DESCRIPTION: A key to Warrior Readiness is how to mitigate the challenges facing human performance on the battlefield, and as information handling and situation awareness increase in importance, cognitive functions take on even greater significance in that performance. In recent years, the DoD modeling and analysis (M&A) community has made considerable progress in developing the analytic tools to address individual combatant (IC) issues, and in particular, in the representation of human behavior (HBR), but the problem of modeling cognition and the effects of performance moderators on cognition remains. Also, the problem of developing models of cognition in which the effects of behavioral moderators can be determined remains to be solved. There exist some performance shaping functions to address individual moderators, but no comprehensive way to integrate the effects of multiple factors has been identified.

A critical component that will support the M&A community in assessing the effects of performance moderators on cognition is the development of an *integrated cognitive architecture* that reflect the process-oriented cognitive functions that provide the psychological foundations for effective decision-making. By effectively modeling individual cognitive processes, we will be better able to understand the effects that behavior moderators have *throughout* the decision-making process.

Particularly desirable are functions that specify a marginal increment or decrement in cognitive performance for various combinations of enhancers or moderators and stressors, leading to corresponding changes in mission capability. Measures of such increments/decrements should take into account the uncertainties in a combat environment. Key inputs to the function include baseline Warrior Systems capabilities, such factors as general health and physical condition, mental and physical stress, cultural norms, environmental stressors (e.g., combat intensity, weather and climate, altitude, information overload), training and experience.

Methodologies such as Operational Requirements-based Casualty Assessment (ORCA) combine physical insults and estimate their effects as elemental capability vectors. This same taxonomic approach may be appropriate for cognitive performance and associated performance moderators, or it may be that other approaches such as multi-attribute utility theory or even selection of most dominants effect may be more appropriate.

PHASE I:
The steps to develop the concept, which will satisfy the first objective are:

Identify specific behavior moderators (e.g., stress, fatigue) and the associated cognitive parameters (e.g., information processing capacity and rates) that these moderators affect within an integrated cognitive architecture.

Evaluate potential algorithmic methods and identify promising methods for developing moderator integration functions. Select one or two such methods for follow-on development. Identify data requirements.

Develop a cross matrix between performance moderator effect and specific mission objectives, tasks, and scenarios. Deliverables will include a detailed report of all findings including data, analyses, and evaluations from the Phase I effort.

The steps to develop the concept, which will satisfy the second objective are:

Identify the stessors that exist in the combat environment (e.g., stress, fatigue, information overload), which impact on cognitive function (e.g., information processing capacity and rates and effective communication and dissemination of information).

Identify candidate behavioral moderators that can attenuate or prevent the adverse impact of the combat stressors on cognitive functioning.

Develop potential models, with the appropriate metrics and necessary algorithms, for testing the proposed combat stressor-behavioral moderator-cognitive function relationships. Select one or two models for follow-on testing and development. Identify data requirements.

Develop or identify the scenario(s) for testing the proposed model. Deliverables will include a prospectus with a literature review, a data collection plan and a model testing and validation plan to be implemented in Phase II.

PHASE II:

Steps to achieve the first objective include algorithm implementation and validation. The algorithm must provide at least one measure of integrated performance functionality that is able to use the inputs identified during Phase I. The algorithm developer is responsible for obtaining existing data such as performance shaping functions that may be available for this effort. The developer is not expected to collect new data during Phase II.

Steps to achieve the second objective include data collection and model implementation and validation. This is the most intensive phase of the proposal. The objectives include; collecting necessary data to evaluate proposed model(s) and validating and test proposed model(s). Deliverables will include a detailed report of all findings including data, analysis, and evaluations of proposed model. That is, were the proposed models validated.

PHASE III DUAL-USE COMMERCIALIZATION: The need for estimating cognitive performance under stress is critical in a number of fields ranging from air traffic control to fire fighting to civilian police operations to medical emergency health care providers. Developers of commercial goods and equipment for military and other applications require a capability to estimate how their products may affect performance in high stress, time-critical environments.

REFERENCES:

1) Pew, R.W., and Mavor, A.S. "Modeling Human and Organizational Behavior: Applications to Military Simulations", National Academy Press, Washington, D.C. (1998).
2) Killion, Ellen M.; *Software Design Document for Operational Requirements-based Casualty Assessment (ORCA)*; Contract No. DAAM01-97-D-0013, Delivery Order 0035; Applied Research Associates, Inc. 4300 San Mateo Blvd. Suite A220 Albuquerque, NM 87110; December 1998.
3) Mulgund, S.S., Harper, K.A., Zacharias, G.L., and Menke, T.E. "SAMPLE: Situation Awareness Model for Pilot-in-the-Loop Evaluation", in the *Proceedings of the 9th Conference on Computer Generated Forces and Behavior Representation*, Orlando, FL, May 2000.

KEYWORDS: Integrated Cognitive Architecture, Cognitive Performance Model, Assessing Cognitive Readiness, Behavior Moderators, Human Performance, Information Handling, Situational Awareness, Human Behavior Representation, Decision-Making, Stressors.

OSD02-CR07 **TITLE**: Measuring Multi-tasking Ability

DoD Technology Area: Human Systems R&D

MAIL PROPOSAL TO: Susan Chipman, Ph.D.
Address: ONR Code 342
800 N. Quincy St.
Arlington, VA, 22217-5660

OBJECTIVE: Develop and validate a practical test of the ability to learn to perform well in time pressured multi-tasking environments, such as those found in military command and control centers or civilian 911 emergency centers.

DESCRIPTION: Some individuals appear to be much more able than others to learn to perform well in time-pressured multi-tasking environments such as command and control centers and 911 emergency centers. At present, there are no selection tests available that do an adequate job of predicting who will prove to perform well in such jobs. As a result, a great deal of money is wasted in training. There may also be critical costs of other kinds during an initial job performance period before an individual's inability to perform well is detected and acted upon by the individual (retention is poor in 911 centers) or the organization. The advent of computerized testing makes it much more feasible to develop selection tests that tap the kinds of skills or abilities relevant to performance in such jobs. Some recent research indicates that it may indeed be possible to develop measures of these abilities that would be practical for use in military and civilian selection processes for such jobs..

PHASE I: Review relevant literature and select or design candidate tests to be used in measuring multi-tasking ability. Design an experimental study to validate these measures and to determine whether they are measuring characteristics distinct from well-established measures of general intelligence or working memory capacities that are already in use. Obtain human subjects approval for the planned study and obtain access to a suitable subject population of adequate size to conduct the planned research.

PHASE II: In Phase II, conduct the experimental study to evaluate the proposed measures, write a report of the research and refine the measures as appropriate. Plan for commercialization if the research results justify it.

PHASE III DUAL-USE COMMERCIALIZATION: Market these new tests if the research results justify it, probably through an existing major vendor of psychological tests. Given the high cost of training many job candidates who do not succeed, there should be a substantial market in the civilian sector as well as the military interest.

REFERENCES:

1) Susan Joslyn and Earl Hunt (1998) Evaluating individual differences in response to time-pressure situations. Journal of Experimental Psychology: Applied, 4, 16-43.

2) Schumacher, E.H., Seymour, T.L., Glass, J.M., Fencsik, D. E., Lauber, E.J., Kieras, D.E., and Meyer, D.E. (2001) Virtually perfect time sharing in dual task performance: Uncorking the central cognitive bottleneck. Psychological Science, 12, 101-108.

3) Yee, P.L., Hunt, E., & Pellegrino, J.W. (1991) Coordinating cognitive information: Task effects and individual differences in integrating information from several sources. Cognitive Psychology, 23, 615-680.

4) Marshalek, B., Lohman, D.F., & Snow, R.E. (1983) The complexity continuum in the radex and hierarchical models of intelligence. Intelligence, 7,107-127.

5) Kyllonen, P.C. (1996) Is working memory capacity Spearman's g? In: Dennis, Ian (Ed); Tapsfield, Patrick (Ed). Human abilities: Their nature and measurement. Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc., pp 49-75.

KEYWORDS: multi-tasking, ability, psychometrics, intelligence, selection, classification, human computer interaction.

OSD02-CR08 **TITLE:** Information Delivery Configuration for Augmented Warrior Readiness

DoD Technology Area: Human Systems, Information Systems Technology

MAIL PROPOSAL TO: Janis Norelli/IFB
26 Electronic Parkway
Rome, NY 13441-4514
315-330-3311 or DSN 587-3311
Janis.Norelli@if.rl.af.mil <mailto:Janis.Norelli@if.rl.af.mil>

OBJECTIVE: Develop inference agents to support the configuration of information delivery to the warfighter in a combination of type, contents and format that maximizes information assimilation and facilitates rapid action.

DESCRIPTION: The past few years have seen increased efforts to develop technologies to support the collection, query, retrieval, filtering and fusion of information from the battlefield. The delivery of the resulting information to the warfighter is often seen as a one-time information visualization design problem. Thereafter, typically the information presentation remains invariable regardless of the changes in the situation, the types and contents of arriving of information, and the cognitive posture of the warfighter that receives and acts upon this information.

In reality, the warfighter confronted with a fast paced flow and the complexity of the evolving battlespace could significantly benefit from a continuously adapting information delivery. Developments in the battlespace generate alternating types of information, each associated with specific modes of presentation and delivery. For example, critical situation notifications can be delivered as symbol changes on a map, as high priority messages in a messaging application, or as alert dialog boxes on the desktop. On another dimension, the warfighter may expect certain categories information to arrive in push mode, or to be retrieved in pull mode when needed. The chance of information actually being assimilated and used by the warfighter in the C2 center or in front of the wearable device when in direct combat, depends on his/her priorities and scope of tasks, on time constraints, display properties and bandwidth characteristics, and the perceptual, assessment and reasoning modes employed in that specific context.

Cognitive warrior readiness, which determines the warfighter's ability to take efficient decisions, is determined by an adequate match between the requirements posed by the warfigher's information processing needs and the description of the new situation. A smart information delivery is needed that is capable to adapt the view of the battlespace to the warfighter's position in the operation, the critical degree of the operation phase, and the tasks s/he is executing. This requires a configuration of the information delivery in a multi-dimensional space defined by the types of information services (e.g., search, messaging, browsing, notification, etc.), the types of information (map overviews, situation updates, logistic and support info, doctrine, regional background info, etc.), and the information format (e.g., textual, tabular, graphical, image-based, etc.)

The objectives of this effort are twofold. First, offerors are expected to identify cognitive readiness criteria that are decisive for configuring information delivery, such as the potential to attend to specific types of information, to different modes of presentation, and the match between contents-type-format combinations of information and the specifics of the warfighter's cognitive readiness in given role-task contexts. Second, offerors are expected to propose and prototype a knowledge management approach interposed between information sources and the warfighter that uses the criteria identified under objective one to continuously evaluate and configure the information being delivered.

PHASE I: The Phase I effort should determine cognitive readiness criteria that can be effectively used to configure information delivery to the warfighter. In addition, the study should identify information delivery dimensions and heuristics and techniques that can be effectively employed to adapt the information delivery in response to cognitive readiness variations previously identified, and select candidate technologies that support the implementation of a configurable information delivery platform. Profiled information delivery should also be addressed based upon information mission needs of the Warfighter in localized battlefield environments.

PHASE II: The Phase II effort should design an architecture and develop a prototype system to demonstrate the viability of the criteria identified in the Phase I study in a selected combat scenario, i.e. joint operations (Army & Air Force or between various echelons within a Command). . The Phase II effort should define performance measures to evaluate variations in decision quality in relationship to the information delivery configurations proposed by the prototype system and show how the information can be automatically profiled and segmented to provide the best local battlefield situational picture without confusing the Warfighter and to allow for quick decision support.

PHASE III DUAL-USE COMMERCIALIZATION: A configurable adaptive platform for information delivery would provide the capability to rapidly assemble user-oriented situation awareness and decision-making environments for warfighters at different echelons from collections of available information sources and channels. The technology has immediate applicability across services and in joint operations. Besides the DoD, the approach would bring considerable benefits to continuing decision-making domains that integrate large collections of incoming information such as mission control centers, traffic and transportation management, and complex industrial process monitoring environments.

REFERENCES:
1) Ch. Baber (2001). “Wearable Computers: A Human Factors Review,” International Journal of Human-Computer Interaction, 13(2), 123-145.
2) D. Benyon (1993). “Adaptive Systems; a solution to usability problems.” User Modelling and User Adapted Interaction, 1993 (available at http://www.dcs.napier.ac.uk/~dbenyon/publ.html)
3) Department of Defense (1999). Defense Technology Area Plan, available through the Defense Technical Information Center.
4) J. Fink, A. Kobsa, A. Nill (1998). “Towards a user-adapted information environment on the Web”, Multimedia and Standardization 98, Paris, France, (available at http://www.fit.fraunhofer.de/~kobsa/publi-all.html).
5) W. Rogers, N. Lamson, G.K. Rousseau (2000). “Warning Research: An Integrative Perspective,” Human Factors, vol.42, no.1, Spring 2000, 102-139.

OSD02-CR09 **TITLE:** Real-time Simulation Network and Human Performance Measurement Device for Distributed Mission Training (DMT)

DoD Technology Area: Human Systems R& D

MAIL PROPOSAL TO: AFRL/HEOP
Ms. Sabrina Davis
2610 7th Street
Wright Patterson Air Force Base, Ohio 45433

OBJECTIVE: To develop a network and human performance measurement device that can be used to efficiently measure and optimize human interaction with simulation devices across DMT networks. The military forces are seeking development of innovative tools and techniques that can be used to efficiently gather and report data to permit optimization and enhancement of human performance through diagnosis of both network and human performance latencies associated with networked real-time simulations, especially those utilizing Distributed Interactive Simulation (DIS) and High Level Architecture (HLA) interconnection technologies.

DESCRIPTION: Current simulation performance analysis tools provide only a limited capability to both gather and analyze simulation data in real-time. Most tools gather data during the simulation run and then perform a lengthy post-run analysis providing results hours to days later. Those systems that do provide for real-time monitoring and analysis focus on technical aspects of network performance and are deficient in measuring human interaction with control and visual display systems. While latencies introduced by network bottlenecks and interconnection methods such as the HLA Run Time Infrastructure (RTI) are significant, those introduced by human interaction systems such as cockpit controls, head-trackers, and image generators must also be accounted for. It is important to determine if training deficiencies are the result of network/hardware limitations or deficiencies in human factors engineering. The developed tools must enable system and training evaluations to be displayed while the simulation is running so that real-time adjustments, where possible, can be made. The tool must not impact the quality or interactivity of the simulation as data is transferred between data collection units. The desired system will be compatible with both the DIS and HLA intercommunication standards and will display information in a format that is easy to understand and will pinpoint potential weaknesses in the quality of the simulation and/or human performance while it is being conducted.

PHASE I: Phase I will develop a prototype network and human performance measurement device that tracks correlation among stimuli, response time and action performed. Phase I will also provide a demonstration and report.

PHASE II: Phase II will result in a fully integrated performance monitoring and measurement capability which is MTA-compliant and which provides the capabilities outlined above. It will also result in test and evaluation of the developed tools and will provide documentation of results in a technical report.

PHASE III DUAL USE COMMERCIALIZATION: The capability to perform real-time network and human performance monitoring, measurement, and diagnosis of problem areas during an interactive simulation exists in only a very limited capacity today. The military will realize a significant reduction in on-the-job training requirements while substantially increasing the capabilities of the operational forces in theater due to the improved training and performance transfer resulting from improved and more realistic training and rehearsal. Phase III dual use potential is significant since both the military and commercial sectors have devoted considerable resources to the development of highly complex operational simulation systems.

REFERENCES:

1) Purdy, Lt. SG Jr., Wuerfel, R., Barnhart, Lt.D., and Ewart, R. (1997). Network Evaluation for Training and Simulation. AFRL-VA-WP-TR-1998-3013.
2) Kniola, T., Thompson, S., Valentino, G., Carlisle, C., Khalil, S., Beatty, D. (1998). SNAPPY: An SMP-Based, Low-Latency, Network Interface Unit and Latency Measurement System – Final Report. AFRL-VA-WP-TR-1998-3051
3) Bryant, R., Douglass, Capt. S., Ewart, R., Slutz, G. (1994). Dynamic Latency Measurement Using the Simulator Network Analysis Project. I/ITSEC conference.
4) Andel, Lt. T., Zydallis, Lt. J (1998). Coyote '98 Data Evaluation. AFRL/VACD report.
5) Barbuceanu, M., & Fox, M.S. (1995). The architecture of an agent building shell. In M. Woodridge, K. Fischer, P. Gymtrasiewicz, N. Jennings, J.P. Muller, & M. Tambe (Eds.), Working notes of the IJCAI-95 workshop in agent theories, architectures, and languages (pp. 264-275), Montreal, Canada.

KEYWORDS: Interactive performance, Simulation Network Analysis Tools, Distributed Interactive Simulation (DIS), High Level Architecture (HLA), Entity Attributes

OSD02-CR10 **TITLE:** Accommodation Engineering and Decision Aide (AEDA)

DoD Technology Area: Human Systems R&D

MAIL PROPOSAL TO: AFRL/HEOP Sabrina Davis
Address: 2610 7th St., Bldg. 441, Rm. 216
Wright Patterson AFB, OH 45433
Phone: (937) 255-2423 x226

OBJECTIVE: Develop technologies that can be used to develop a web based, comprehensive, international 3-D human shape, fit, and performance information system, as well as new visualization and expert system tools to make the information more usable, and methods for acquiring additional data on performance and dynamic accommodation parameters in a manner which is readily incorporated into the information system.

DESCRIPTION: The USAF Surgeon General's office reports 9% of aircraft mishaps implicate pilot size as a contributing factor. There are also numerous problems with the fit of personal protective equipment and apparel that effect military personnel performance and safety. Even unmanned vehicles are experiencing ergonomic problems in their operator stations. These problems can be much worse for international populations using our equipment because of quite different anthropometric (body size and shape) distributions. For example, the Dutch experienced dramatic accommodation problems when they purchased the Apache helicopter. Improved and readily accessible knowledge of fit and population accommodation is essential for effective and safe operability and interoperability of our equipment systems. New types of 3-D fit and accommodation data are available but the data is not in a form accessible to the designers and decision makers who need this information. The challenges in this effort include: 1) the collation of existing 3-D anthropometry, other 3-D objects, traditional flat file data, fit and accommodation data bases into a single international resource, 2) development of searching tools and decision support methods to find information in the resource, 3) gathering new data on operator posture, tissue properties, performance, and injury rates related to spinal alignment, and 4) development of methods to help users evaluate, see and understand the information (e.g, immersive methods for visualizing fit and accommodation). The products developed must be suitable for implementation in a searchable information resource for use in: 1) writing international anthropometric requirements for acquisition of equipment systems, 2) engineering for improved accommodation and interoperability of equipment systems, 3) assessment of the interoperability capabilities of existing systems and 4) determining optimal warfighter and equipment size combinations.

PHASE I: Phase I should identify technology concepts that addresses one or more of the challenges for the utilization of 3-D human body and equipment data, accommodation information and new methods for data acquisition in a standardized manner for direct user input into the information system.

PHASE II: In Phase II, a prototype of the new technology should be developed and demonstrated for evaluation by users over the web.

PHASE III DUAL-USE COMMERCIALIZATION: Given that our 3-D human body scan data, available on the civilian populations of NATO countries, was obtained with funding support from 34 commerical companies it is clear that this system will have a broad commerical market. Industries that will benefit from such a system include automotive, clothing, protective equipment, furniture manufacturing, medicine, and aerospace. The Phase III effort should focus on incorporating data into the system from around the world and expanding the visualization and user interface for the broader market.

REFERENCES:

1) Li, P., Corner, B.D., Paquette, S., Lee, C., Kim, I.Y. (2000) "Analysis of air gap size and distribution in single and multi-layer clothing systems using 3-D whole body digitizing", in Proceedings of the International Ergonomics Association XIVth Triennial Congress and Human Factors and Ergonomics Society-44th Annual Meeting, pp. 6-758 to 6-761, Human Factors and Ergonomics Society Inc., Santa Monica, CA.
2) Meunier, P. (2000) "Use of body shape information in clothing size selection", in Proceedings of the International Ergonomics Association XIVth Triennial Congress and Human Factors and Ergonomics Society-44th Annual Meeting, pp. 6-715 to 6-718, Human Factors and Ergonomics Society Inc., Santa Monica, CA.
3) Nurre, J. (1997), "Locating Landmarks on Human Body Scan Data", IEEE Computer Society Press, International Conference Recent Advances in 3-D Digital Imaging and Modeling, pp 289-295.
4) Nurre, J. H., Whitestone, J. J., Burnsides, D. B., Hoeferlin, D. M. (1995). "Issues for data reduction of dense three-dimensional data." SPIE Vol. 2588, p. 618-625, Intelligent Robots and Computer Vision XIV.
5) Paquet, E., Robinette, K.M. and Rioux, M. (2000) "Management of three-dimensional and anthropometric databases: Alexandria and Cleopatra", in Journal of Electronic Imaging Vol. 9, Issue 4, ,pp. 421-431, SPIE-The International Society for Optical Engineering, Bellingham WA
6) Robinette, K.M. (2000). "CAESAR Measures Up." Ergonomics in Design, Vol. 8, No. 3, pp. 17-23. The Human Factors and Ergonomics Society, Santa Monica CA.
7) Robinette, K.M. (2000) "3-D Fit Mapping" in Proceedings of the International Ergonomics Association XIVth Triennial Congress and Human Factors and Ergonomics Society-44th Annual Meeting, pp. 6-735 to 6-738, Human Factors and Ergonomics Society Inc., Santa Monica, CA.

KEYWORDS: Apparel, Patterns, Body forms, Sizing, Anthropometry, Automation.

OSD02-CR11 **TITLE:** Identifying and Capturing the Cognitive Demands Imposed by New Systems

DOD TECHNOLOGY AREA: Human Systems

MAIL PROPOSAL TO: Sabrina Davis
2610 7th St., Bldg 441, Rm. 216
Wright Patterson AFB, OH 45433
PHONE: (937) 255-2423 x226

OBJECTIVE: The primary objective of this SBIR is to aid Program Managers and the design team of new systems that will operate in future environments understand the cognitively complex tasks and team dynamics involved in operating those systems. The secondary objective is to assist Knowledge Acquisition (KA) activities that feed the representations of the operators' cognitive activities in the constructive simulations supporting system acquisition trade-studies.

DESCRIPTION: As information technologies become more central to weapon systems, the burden is shifting from conventional human factors requirements to the cognitive requirements of operating systems designed around data flow and information management. The Program Manager and design team need tools that enable them to anticipate the cognitive demands placed on the operators of these systems. Cognitive Engineering (CE) is a discipline that was developed to help provide the necessary insight into these human cognitive requirements. Unfortunately, CE has not yet had the impact that is needed. CE strategies applied in research and development efforts need to be transitioned to more general and practical strategies that would provide information useful for Program Managers and designers.

To date, CE methods have been applied primarily to individual workstations. Methods for Cognitive Task Analysis (CTA) almost exclusively support individuals. However, when a Program Manager needs to be concerned with team functions at an early stage of design, the team composition and the requirements for team coordination are of equal or greater concern than are the requirements of individual operators. CE techniques need to extend the current research to address team coordination, rather than continuing to emphasize design for individuals. The assumption that a team is a collection of individuals (along with its corollary, that if we improve the performance of all the individual members, then the team performance should also benefit) ignores the emergent properties of teams (e.g., communication needs, information management, coordination issues, requirements for shared situation awareness), and is not always valid. Better methods are required for understanding and supporting team performance. Team performance is assumed to be a function of several factors including individual workload, communication among team members, coordination of resources, distribution of responsibility, information processing efficiency, and information transfer efficiency.

The CE activities applied to provide information useful for Program Managers and designers in regard to cognitive demands placed upon individuals and teams by the new system can also feed the acquisition team's Knowledge Acquisition (KA) process. KA is the process of acquiring knowledge from various sources with the purpose of formalizing that knowledge in such a way that it can be implemented in computer models (e.g., models of human behavior). KA has long been regarded as a time-consuming and costly process and is currently more of an art than a science. The reusability of previous KA efforts is currently limited -- it seems necessary to start a completely new KA-effort for every application. More cost-effective development of models of human behavior requires that products of KA efforts be reusable, not only by a single practitioner, but also by the larger community.

The Cognitive Engineering product of this work will be a technology to help the system design team address cognitive requirements of teams early in the design cycle – with a focus on decisions rather than procedures – that is consistent with user-centered design concepts. This product will help Program Managers and other members of the system design team address decision-making aspects of teams from early in the design cycle through system test, evaluation, and modification phases. This product is to enable the designers to generate more effective designs, identify important questions that trigger research activities, set cognitive criteria for the contractors who will be engaged in the detailed system design, and specify acceptance criteria to be used during test and evaluation.

The Cognitive Engineering product will form the basis for a Knowledge Acquisition product that the system design team can exploit for KA throughout the system life cycle.

Payoffs include: (a) placing cognitive requirements in the mix of design criteria from the beginning affords protection to the operators by making their needs a viable part of the design process, (b) a better match between system functions and human cognitive and physical capabilities; (c) tools to support optimization of system performance and workload, (d) better understanding of knowledge, skills, and abilities needed, and (e) enhanced training system design as a result of this better understanding.

PHASE I: A descriptive framework will be completed. A final report will document issues, the framework, reviews, progress, findings, and a Phase II research plan.

PHASE II: A breadboard will be developed and evaluated for a given military-based application. This breadboard will provide a demonstration of: (a) a capability to acquire knowledge in a way that makes the cognitive demands of individuals and teams clear to a Program Manager and system design team and (b) a capability to exploit this knowledge acquisition for reuse by a Knowledge Engineer in representing human behavior in constructive simulations. A final report will document issues, needs and requirements, tradeoffs, problems, and findings.

COMMERCIAL POTENTIAL: This product is applicable to the conceptual design of any complex system that includes human components. Examples include air and space vehicles, air traffic control, space mission control, metropolitan emergency management, nuclear power plants, and police command and control units.

REFERENCES:

1) Defense Modeling & Simulation Office (DMSO), Human performance working group, http://www.dmso.mil/public/thrust/hp/
2) Landauer, T. K. (1995). The trouble with computers: Usefulness, usability, and productivity. Cambridge, MA: MIT Press.
3) McDermott, P., Klein, G., Thordsen, M., Ransom, S., & Paley, M. (2000). Representing the cognitive demands of new systems: a decision-centered design approach. Air Force Research Laboratory, Wright-Patterson AFB, OH. AFRL-HE-WP-TR-2000-0023.
4) RTO Technical Report 47. (2001) Human behaviour representation. NATO research & Technology Organization, 7 Rue Ancelle, F-92201 Neuilly-sur-Seine, Cedex, France. (pp. 74-77).
5) Pew, R.W. & Mavor, A.S. (Eds.) (1998). Modeling human and organizational behavior: application to military simulations, National Research Council, National Academy Press, Washington DC.

KEYWORDS: cognitive engineering, cognitive task analysis, knowledge acquisition, knowledge engineering, decision-centered design, cognitive requirements, decision making, analysis of alternatives, constructive simulation, human behavior representation, team interaction representation, human-centered design, human interaction, human-system interface, weapon systems acquisition

OSD02-CR12 **TITLE**: Application of Culturally Specific Aspects of Human Behavior to Adversarial Decision-Making

DoD Critical Technology Area: 11. Human Systems

MAIL PROPOSAL TO: Sabrina Davis
AFRL/HEOP
2610 7th ST, Bldg 441, Rm 216
Wright-Patterson AFB, OH 45433
Phone: (937) 255-2423 x 226

OBJECTIVE: Identify feasibility of enhancing extant human behavior models by incorporating cultural and group factors in behavior into them. Evaluate ability of these enhanced models to: a) improve accuracy of behavior modeling and behavior prediction; b) provide enhanced support for the Information Operations (IO)/Psychological Operations (PSYOP) commander or analyst; and c) outline additional data collection requirements necessary to support the development of these enhanced models.

DESCRIPTION: In Asymmetric Warfare and Operations Other than War strategists and operational-level troops will likely encounter opponents very different from traditional fielded military forces. Opposition forces will likely feature individual, highly idiosyncratic decision-making, non-traditional social networks, and be characterized by a high degree of uncertainty and general unpredictability. Additionally opposition leaders in this setting will likely be people we know little about individually.

A military planner's principal guide in such a situation will be an understanding of the cultural milieu of the opposition force and its leadership. Such an understanding will aid us in predicting their initiatives and responses to the unfolding military situation. Additionally events in a leader's personal affair, e.g., changes in financial state, health, personal relationships, opportunities for advancement, will likely influence his military decisions, and reactions to such events are also significantly affected by culture.

Research advances in the areas of cognitive, social, and organizational modeling, in conjunction with advances in social network analysis, offer significant potential for understanding enemy behavior and enemy courses of action in the AWE / OOTW environment (Schweitzer et al., 1999; Illgen et al, 1997; Pew and Mavor, 1998; Hudlicka & Pfautz, 2002).

We can greatly improve our efforts to predict the behavior or adversaries in asymmetric warfare and operations other than war by incorporating cultural and sub-cultural factors into our behavior models. In particular, this will improve our ability to predict how such adversaries will respond to our actions, and which actions on our part are most likely to be successful. It will also allow us to efficiently and effectively focus intelligence-gathering efforts into areas likely to produce useful information. It will improve our ability to predict future initiatives of the adversary or potential target and the on-scene commander's ability to prepare to counter them. It will improve the commander's ability to initiate operations that are most likely to be successful. As one's interpretation of and response to information is highly culture-specific, we will improve our ability to mount information warfare operations that are likely to be successful. Integration of reliable culture-specific information about potential adversaries into wargaming scenarios will make wargaming a more valuable experience for participants in preparing them for real-world operations.

PHASE I: Review of applicable research areas and enabling technologies will be demonstrated within a proof-of-concept decision-aid prototype. The prototype will address the following issues: behavioral modeling within the asymmetric warfare/operations other than war environment (WAE/OOTW); the ability to integrate cultural factors within these models; and the ability to infer individual characteristics from knowledge of cultural context in such a way as to be applicable to e.g. dismounted infantry or close air support operations.

PHASE II: Full-scope implementation of the decision-aid prototype and evaluation across a range of WAE/OOTW scenarios, with an attendant database of relevant information on a large sample of cultures.

PHASE III DUAL-USE COMERCIALIZATION: Both the human behavior models and the decision aid prototype will be applicable within a range of commercial areas, including business intelligence, industrial counter espionage, high-level diplomatic negotiations, and a variety of team and organizational training environments.

REFERENCES:
1) Chase, C.B. (1990). In the Mind's Eye: Cultural Influence in Decision Analysis and Strategic Planning. Monterrey, CA: Naval Postgraduate School.
2) Hudlicka, E. and Pfautz, J. (2002). Architecture and Representation Requirements for Modeling Effects of Behavior Moderators. In Proceedings of the 11th Conference on Computer Generated Forces and Behavioral Representation, Orlando, FL.

3) Illgen, C., Zacharias, G. and Hudlicka, E. (1997). A Decision-Aid for Command and Control Warfare. Report No. R94621. Cambridge, MA: Charles River Analytics.
4) Lesser, I.O. (1999). Countering the New Terrorism. Washington, DC: Rand Corporation, http://www.rand.org/publications/MR/MR989 .
5) Pew, R.W. and Mavor, A.S. (1998). Representing Human Behavior in Military Simulations. Washington, DC. National Academy Press.
6) Staten, Clark L. (1998). Asymmetric Warfare, the Evolution, and Devolution of Terrorism: The Coming Challenge for Emergency and National Security Forces. Chicago, IL: Emergency Response & Research Institute, http://www.emergency.com/asymetrc.htm.
7) Vockery,W.N. (1996). Future Conflict: Force XXI against the Asymmetric Opponent. Ft. Leavenworth, KS: Army Command and General Staff College, DTIC ADA314 915.

KEYWORDS: Human behavior modeling, individual and group behavior modeling, cultural factors, human behavior moderators, Information Operations (IO), Operations Other Than War (OOTW) and Warfare in the Asymmetric Environment (WAE).

OSD02-CR13 **TITLE**: Design of Sharable Content Objects with Return on Investment

DoD Technology Area: Human Systems R&D

MAIL PROPOSAL TO: Naval Air Warfare Center Training Systems Division
Attention: Carol Robinson, Code 4973
12350 Research Parkway
Orlando,FL 32826-3275 Phone: (407)380-8393

OBJECTIVE: The purpose of this SBIR is to enhance Advanced Distance Learning (ADL) on the Web through intelligent design and authoring software that is based on pedagogical issues, principles and standards while focusing on learning object definitions that reap a return on investment.

DESCRIPTION: The SCORM information model for meta-data tags has several sections that require additional review and consideration before the visions for ADL can be made reality. Educational, testing, and relationship data elements are examples of sections that can be extended as a basis for better descriptions of the instruction. These are dependent upon techniques for defining learning objects that are not only interoperable among LMSs but discoverable in repositories by both course developers and learners.

PHASE I: Define techniques to support design and authoring of learning objects, with both pedagogical underpinnings and practical, object- oriented considerations. Develop both a set of meta-data content and elements that provide a pedagogical basis and a return on investment model for sharable content objects.

PHASE II: Develop prototype design and authoring software to support instructional design of sharable content objects. The software should generate the pedagogical metadata and allow ingest into a repository for discovery.

PHASE III: Refine the prototype software, test the pedagogical underpinnings and support for accessibility through LMS and repository software.

COMMERCIAL POTENTIAL: Web-based learning has increased substantially in the past few years. Standardization of meta-data tag elements and content is considered by industry to be a key to interoperability and reusability.

KEYWORDS: Advanced distributed Learning, Web based Learning, SCORM, meta-data

OSD02-CR14 **TITLE**: Multi-Modal Visualizations for Virtual Environment Training Systems

DOD TECHNOLOGY AREA: Human Systems R&D

MAIL PROPOSAL TO: Naval Air Warfare Center Training Systems Division
Attention: Carol Robinson, Code 4973
12350 Research Parkway
Orlando,FL 32826-3275 Phone: (407)380-8393

OBJECTIVE: Develop effective multi-modal visualization design guidelines from the perspective of human information processing, problem solving, and visual display theories and to empirically test and validate determined guidelines using efficient sequential experimentation techniques. Then, utilize such knowledge to enhance the effectiveness of current and future training system designs.

DESCRIPTION: The potential of VE technology as a tool for creating effective multi-modal training environments may not be fully realized until the following guiding principles are identified from the current and future state of knowledge in the visualization and VE fields: how to identify which attributes are most important for a given domain or user, how the attributes should be represented (e.g., via multi-modalities, 3D versus 2D), which interaction technique(s) is most appropriate, when an immersive or a non-immersive VE may be more effective, or when a traditional desktop environment may be sufficient. Without such knowledge and guidance, designers may produce perceptually ambiguous displays too complex, if not impossible, to interpret, thereby hindering rather than facilitating the user's decision-making process, abstract reasoning capabilities, and overall performance (Kalawsky, 1993).

Many believe the common adage that "a picture is worth a thousand words," yet not all pictures are equally communicative. Information processing theories suggest that to achieve comprehension of visual displays they must be developed such that they are readily perceived, interpreted, and acted upon. By designing an interface that appropriately and consistently maps perceptual features of a display to the goal-relevant domain properties, the visual representation may support the development of an accurate mental model (Robertson, 1990, 1991). Thus, continued interaction with the visualization should facilitate information comprehension and streamline data access (Thüring, Hannemann, & Haake, 1995). For instance, considering that the cost of visually sampling (i.e., fixating on a particular area and extracting the pertinent information from it) a visual display is inversely proportional to the ease with which the display can be interpreted by the user, a number of factors must be accounted for in order to improve display interpretation by minimizing sampling costs (Ware, 2000). These factors include such issues as determining: the spatial proximity of points to be sampled for comparison; the interval at which intermittently displayed items should be presented (e.g., people are much more reliable at monitoring information presented at one-minute intervals versus 20-minute intervals), and; which information is goal-relevant and thus should be displayed. There is a need to identify methods to aid visualization designers in identifying goal-relevant domain properties for particular domains and tasks.

Recent research in identifying display techniques for facilitating problem solving involves the utilization of different display modalities (i.e., visual, audio, tactile) (Turk & Robertson, 2000). Mills and Noyes (1999) suggest that early studies support the notion that the multi-modal aspect of VEs may result in enhanced human performance. For instance, Breaux, Martin, and Jones (1998) suggest that a primary advantage of VE technology is that it enables a training environment to be manipulated by both the instructor and the student to facilitate the integration of knowledge into an appropriate mental model, thereby enhancing learning and improving performance. It is also generally accepted that dynamic or interactive visual displays (e.g., VEs) facilitate a user's understanding of complex relations between represented parameters (Kalawsky, 1993). Moreover, it is theorized that VE technology may be an effective visualization tool for teaching and learning because it makes better use of the human central nervous system's ability to handle a rich set of sensory inputs (e.g., sight, sound, touch) (Doyle & Cruz-Niera, 1999). There is a need to better understand the utility of extending visualizations into multi-modal presentations.

PHASE I: Identify generalizable, goal-relevant domain attributes for multiple application/task domains with respect to their inherent visual, aural, and haptic primitives. Develop a systematic empirical strategy to develop multi-modal design guidelines, as well as validate new guidelines as they emerge.

PHASE II: Test visualization guidelines for tasks fundamentally based on visual performance attributes for generalization to multiple application domains Test guidelines based on auralization of specific task attributes, which may enhance the performance of the determined task(s), with the following treatment levels: visual, aural, and visual + aural. Test haptic presentation guidelines, which may enhance the performance of the determined task(s), with haptic, visual + haptic, aural + haptic, and visual + haptic + aural).

PHASE III: DUAL-USE COMMERCIALIZATION. Apply guidelines to Navy VE based training system to enhance the performance of trainees and facilitate the instructor grasp of the student's skill levels.

REFERENCES:

1) Breaux, R. B., Martin, M., & Jones, S. (1998). Cognitive precursors to virtual reality applications. In Proceedings of SimTecT (pp. 21-26), Adelaide, S. Australia, March 2-6.
2) Doyle, P., & Cruz-Neira, C. (1999). Virtual reality and visualization in education. Syllabus: New Directions in Education Technology, 12(9), 18-22.
3) Kalawsky, R. S. (1993). The science of virtual reality and virtual environments. Wokingham, England: Addison-Wesley.
4) Mills, S., & Noyes, J. (1999). Virtual reality: an overview of user-related design issues. Interacting with computers, 11(4), 375-386.

5) Robertson, P. K. (1990). A methodology for scientific data visualization: Choosing representations based on a natural scene paradigm. In Proceedings of Visualization '90 (pp. 114-123). Los Alamitos, CA: IEEE.
6) Robertson, P. K. (1991). A methodology for choosing data representation. IEEE Computer Graphics and Applications, 14, 56-67.
7) Thüring, M., Hannemann, J., & Haake, J. (1995). Hypermedia and cognition: Designing for comprehension. Communications of the ACM, 38(8), 67-66. Ware, C. (2000). Information visualization: Perception for design. San Diego: Academic Press.
8) Turk, M., & Robertson, G. (2000). Perceptual user interfaces. Communications of the ACM, 43(3), 33-34.

OSD02-CR15 **TITLE:** Web-based Game Design Advisor

DoD Technology Area: Human Systems R&D

MAIL PROPOSAL TO: Naval Air Warfare Center Training Systems Division
Attention: Carol Robinson, Code 4973
12350 Research Parkway
Orlando,FL 32826-3275 Phone:(407)380-8393

OBJECTIVE: The purpose of this SBIR is to explore concepts leading to the development of a tool for designing online game-based training and reworking existing games to meet training objectives.

DESCRIPTION: Research into the use of instructional games has yielded promising results. Well designed training games can lead to improved learning (Whitehall and McDonald, 1993; Ricci, Salas, & Cannon-Bowers, 1996). Just as important is the motivational value of instructional games, especially in the context of distance learning. Without the face-to-face guidance of an instructor, distance learners bear what is sometimes an overwhelming responsibility for their own motivation. The cycle of procrastination, falling behind, and dropping out is an all too common phenomenon in the world of online learning. Harnessing and holding a distance learner's attention is critical. Ultimately, the goal of a training game is to trigger a "game cycle": a repeating loop of the game player's self-motivated engagement with the material, persistence, and a desire to return to the game in an effort to gain increasing skill levels (Garris, Ahlers, and Driskell, in press). Garris and Ahlers (2001) showed that adding gaming characteristics (e.g., scoring, and visual and sound effects) to a pc-based trainer resulted in trainees expressing greater commitment to learning goals and increased confidence in their ability to learn the material.

The military is investing heavily in the development of face-to-face simulations that capitalize on gaming strategies (e.g., simulated foes and weapons). Less attention has been paid to developing training games that can be played over the web either as part of a distance learning curriculum or as stand-alone training. These games can be used for a broad range of purposes: from community building for distance learning participants, to introducing a topic (with the goal of holding the interest of the learners), to training situational awareness and tactical decision-making. Instructional goals should drive game design. For example, if the goal is to encourage the student to engage in a game cycle with the instructional materials (i.e., return repeatedly), the developer might want to incorporate motivational features such as competitive scoring, game levels, and rewards for achieving increasingly advanced skills. However, if the goal of the instructional game is primarily to introduce the training material that is to follow, the developer might want to let the students play, see the results of their actions and see how other scenarios might have played out if the game players made different decisions. In this case, there would be little emphasis on competition and scoring. Similarly, if the goal is to make students more confident in their ability, the game should allow for early success, and then build in difficulty slowly. Details might be held to a minimum to ensure that students focus on the salient issues. In contrast, if the goal is to have students hone their situational awareness abilities, more difficulties could be introduced early on, and more contextual variables should be presented. They could then be trained to extract important elements from the flow of information, understand it in terms of mission elements, and then project near term probabilities affecting mission success. Clearly, there is a great deal of information to consider in the development of training games. Further, there is currently little guidance on how to design games for the broad range of potential applications. A great deal of useful information could be extracted from existing training literature and applied to instructional gaming. A tool is needed to make this task easier for the online game developer.

PHASE I: Explore alternative approaches and the feasibility of an on-line tool for the development of instructional games to be used in the context of distance learning. The contractor shall formulate detailed plans for 1) building a prototype assistant and 2) testing its usefulness and effectiveness. The plans for the prototype shall provide justification for the chosen content based upon an in-depth understanding of Navy, Marine Corps, Air Force, Army, or DoD DL requirements. It shall be capable of installation on an existing Department of Defense DL network (e.g., Navy ADL, Marine Net, Total Army Distance Learning Program, or the DoD ADL Co-Laboratory). The plans for prototype development shall also include methods to ensure compliance with DoD SCORM for the resulting content.

PHASE II: Following the plans formulated during Phase I, the contractor shall provide a more detailed analysis of the specific context for development and implementation. The contractor shall then develop, test, and demonstrate the prototype game development tool. The phase II game development product will demonstrate how to build a game to teach situational awareness in the context of a ground forces task.

PHASE III DUAL USE COMMERCIALIZATION: The contractor shall produce a technology demonstration based on the prototype system developed under Phase II. This technology demonstration will consist of demonstrating the game development tool, and the content will be evaluated at a DoD training facility. There are many potential applications for a tool to improve the quality of instructional games within and outside the military. Many commercial organizations are using games to train their personnel in a wide variety of tasks. Once the tool has been shown to improve the quality of game design in military distance learning, we expect that commercial developers will be eager to use it as well.

REFERENCES:

1) Garris, R.; Ahlers, R. "A game-based training model: Development, application, and evaluation. Paper presented at I/ITSEC, November, 2001
2) Garris, R.; Ahlers, R. ; Driskell, J. "Games, motivation, and learning: A research and practice model." Manuscript in preparation.
3) Ricci, K.; Salas, E. ; Cannon-Bowers, J. A. "Do computer-based games facilitate knowledge acquisition and retention?" Military Psychology, 8 (4), 295-307, 1996.
4) Whitehall, B.; McDonald, B. "Improving Learning Persistence of military Personnel by Enhancing Motivation in a Technical Training Program" Simulation & Gaming, 24(3), 294-313, 1993.

KEYWORDS: distance learning; training games; motivation; instructional design

DDR&E Science and Technology Focus Area
Wireless Technology

The Deputy Under Secretary of Defense for Science and Technology has established a focus area to explore wireless technology research issues. Wireless technology is a recent focus inspired by extraordinary technological advances in this technology, by tremendous interest in this technology on the part of researchers and system designers and by the emergence of the Internet as a real-time communication tool. The near future will see a proliferation of wireless communication available for battlefield use. Commercial and military space technology and systems will provide major leaps in coverage, timeliness, and resolution. Many efforts in these areas are ongoing in the Services and Agencies, and together could provide a tremendous new warfighting capability. The overall vision of this area is to develop the tools necessary to adapt and exploit, as well as understand this new technology in order to greatly enhance our warfighting capability.

We have chosen the following four topics and Service Laboratory Executive Agents to manage the SBIR topics in this technology area:

- OSD02-WT01 Develop Wireless LAN Design & Validation Tools, Navy SPAWAR
- OSD02-WT02 Intrusion detection for 802.11 networks, Navy NSWC, Crane
- OSD02-WT03 Wireless LAN Design Tools, Navy NSWC, Crane
- OSD02-WT04 Self-Configuring Hub-less Wireless Network , Naval Sea Systems Command and NSWC, Dahlgren

The Wireless Technology SBIR Topics are on the following pages.

OSD02-WT01 **TITLE:** Develop Wireless LAN Design & Validation Tools

DoD Technology Area: Wireless LAN R&D

MAIL PROPOSAL TO: Commanding Officer
Naval Sea Systems Command
ATTN: 05R1 Richard Milligan
1333 Isaac Hull SE STOP 5172
Washington Navy Yard, DC 20376-5172

OBJECTIVE: Develop the following Wireless Local Area Network (WLAN) Design and Validation tools:
(1)Survey tools that determine, measure and locate interference in the 802.11a/b spectrum in a complicated military environment where there is vulnerability to security, electromagnetic interference (EMI) and ordnance.
(2)Survey tools that determine multi-path interference in a military environment described in (1) .
(3) A tool is required that will generate traffic at adjustable rates and measure the throughput, errors, and collisions between any two points on the WLAN.

DESCRIPTION: Wireless Local Area Network (WLAN) Design and Validation tools are desirable and would reduce what is currently a trial and error process for each installation.
(1) There are many EMI and Radio Frequency Interference (RFI) generators on platforms, such as electronic equipment, microwave ovens, and rogue APs that will degrade the performance of the WLAN if not compensated for in the design. A tool is needed that can be used during a site survey to determine the existence of EMI/RFI in the 802.11a/b spectrums and aid in determining a method to eliminate the impact of this interference on the WLAN. The tool should use directional antennas or other means to assist locating interference sources.
(2) Military environments with steel walled compartments can be very difficult when it comes to positioning RF equipment, due to obstructions and combinations of both large and small spaces. A survey tool is needed that can be used during a site survey to determine when multi-path interference will be encountered and aid in determining a method to eliminate the impact of this interference on the WLAN. (3) The nominal transfer rates of the most commonly used Internet Protocol (IP) protocols must be measured between certain critical points in the WLAN, such as uplinks to core and distribution devices or between clients and APs. A tool is required that will generate traffic at adjustable rates and measure the throughput, errors, and collisions between any two points on the WLAN. Examples of protocols to be measured are Transmission Control Protocol(TCP), User Datagram Protocol (UDP), and Internet Control Message Protocol (ICMP). The size of the packets generated should be adjustable.

PHASE I: The proposal for Phase I should identify the tools to be delivered, the technologies to be used, how the tools will work and specifically what the tools will do. A plan of action and milestones is required. Explanation of why these tools will work in the described military environment is required. The result of Phase I will be working models of the tools. The contractor shall also provide reports that details the concept, metrics and life-cycle costs.

PHASE II: Development of prototype level functioning tool.

PHASE III DUAL-USE COMMERCIALIZATION: Development of production level products that have value in both the commercial and government sectors.

REFERENCES:

1. http://grouper.ieee.org/groups/802/11/
2. ANSI/IEEE Standard 802.11, 1999 Edition
3. IEEE Std 802.11a-1999 or ISO/IEC 8802-11:1999/Amd 1:2000(E)
4. IEEE Std 802.11b-1999
5. IEEE Std 802.15.1-2002
6. Draft DoD Wireless Policy (DoDD 88XX.aa, Version 4.2b, April 01, 2002)
7. ISNS PPL/QPL Test Report: Wireless Local Area Network (WLAN), August 31, 2000, SPAWAR, Rev 2.1, Integration Test Facility, SSC SD.
8. White Paper: Going Wireless, By LCDR David R. Klain, USN, 2001

KEYWORDS: Wireless, RF, Local Area Network, WLAN, LAN, Open Systems, Artificial Intelligence, Expert Systems, Genetic Algorithms, Design Tool

OSD02-WT02 **TITLE**: Intrusion detection for 802.11 networks

DoD Technology Area: Wireless Technology

MAIL PROPOSAL TO: Commanding Officer
Naval Sea Systems Command
ATTN: 05R1 Richard Milligan
1333 Isaac Hull SE STOP 5172
Washington Navy Yard, DC 20376-5172

OBJECTIVE: Provide directional indication of intrusion attempts to wireless data networks, assessment of threat and recommend responses.

DESCRIPTION: There has been resistance to using Wireless networking in military environments due to the very nature of the signals wide area of detection. The commercial interest and development of useful products has, however, made the use of such products appealing despite the inherent risk of detection and interception.

The largest and most militarily useful groups of product are those designed around the Institute of Electrical and Electronic Engineers (IEEE) Local Area Network (LAN) working group 802.11 (Wireless). These products form the basis for portable computer, Personal Data Assistant(PDA) devices and other battery operated devices which can benefit from wireless roaming over 10 to 100 meter distances. The risk however is that reliable omni-directional communication for devices at 100m requires a signal strength easily detected at greater distances.

The industry approach has been to layer data encryption onto the wireless signal with first 40 bit and then 128 bit encoding. The commercial tolerance to encryption is limited and will likely never reach the level of confidence the military requires. To date, the only military answer is to be very selective about the data at risk for interception by strictly limiting the data on wireless accessible networks. Even with attempts to limit exposure through wireless LANs, additional tools to protect the wireless communication are needed.

One specific threat is a new breed of recreational and malicious intruders. While the 1980's saw the advent of "war dialing" to find unsecured modem connections, the new sport is "war driving" hunting for open wireless networks. Just as in the '80's, military facilities can be expected to suffer repeated attempts at such intrusion tactics and should be proactive in detecting such intrusion attempts.

While it is a difficult task to control emissions or external attempts to gain access, it should be practical to detect any transmitters (possibly attempting unauthorized access) outside the intended coverage area.

PHASE I: Identify tools available for detecting intrusion attempts and the applicability to military and naval environments. Using commercially available hardware in unique ways and developing software, provide system administrators with the earliest practical warning of intrusion attempts and locations. Provide report that details the concept, metrics and life-cycle costs.

PHASE II: Investigate the potential of a set of highly sensitive and directional antenna (fixed or rotating) to detect and locate signals even before they are within useful data exchange range and provide software to assess threat and recommend a response.

PHASE III: Dual Use Commercialization: Many industries could find it useful to detect wireless devices approaching their network and evaluate the threat of unauthorized attempts to gain access.

REFERENCES:

1) The Institute of Electrical and Electronics Engineers (IEEE) Local Area Network/Metropolitan Area Network (LAN/MAN) working group 11, Wireles LAN. http://grouper.ieee.org/groups/802/11/

2) James Voorhees. The Limits on Wireless Security: 802.11 in early 2002**,** http://rr.sans.org/wireless/limits.php, January 30, 2002

3) Keeney, Frank. 2001. "Vacation War Driving from Pasadena, CA to San Francisco, CA." URL: http://www.pasadena.net/vacation.

KEYWORDS: wireless, instrumentation, control, machinery monitoring

OSD02-WT03 **TITLE:** Wireless LAN Design Tools

DOD Technology Areas: Information Systems, wireless technology

MAIL PROPOSAL TO: Commanding Officer
Naval Sea Systems Command
ATTN: 05R1 Richard Milligan
1333 Isaac Hull SE STOP 5172
Washington Navy Yard, DC 20376-5172

OBJECTIVE: Develop computer-based wireless LAN design tools to reduce the costs of designing wireless LAN systems and to aid in developing cost-effective WLAN solutions for military platforms, facilities and missions.

DESCRIPTION: The wireless LAN technology market has undergone explosive growth in recent years. There are a large number of different technical solutions and products, each with their own advantages and disadvantages. Developing a wireless LAN solution also has additional challenges over developing a traditional, wire-based LAN. These challenges are compounded for unusual environments such as Naval vessels, military facilities and some commercial facilities such as hospitals or communications infrastructure facilities. In designing a wireless network solution factors such as RF attenuation, reflection and interference must be considered. Security issues must also be given special attention. Designing a cost-effective WLAN solution for military applications and environments that meets all of the special requirements of the DoD is a complicated endeavor.

A tool or suite of tools is needed to assist the designers of WLAN systems for such complex environments and applications. These tools would perform a variety of analyses required for the design of a cost-effective solution that meets DoD requirements. These functions would include:

- Trade-off/comparison analyses between many different WLAN characteristics such as:
    - Access Point (AP) placement
    - Wireless protocols/technologies
    - Security options
- Automatic generation of suggested solutions using 3D models, physical simulation and advanced heuristics or artificial intelligence approaches such as expert systems, genetic algorithms or neural networks. The system should take as inputs various requirements such as: desired coverage, security, bandwidth, a 3D model of a platform or facility and equipment and installation costs. The output would include locations and types of access points and WLAN protocols. An explanation capability is desirable to explain why certain design choices were made.

    Trade-off analyses would provide comparison information for physical characteristics such as coverage and bandwidth as well as cost comparisons for equipment and installation.

    Security options should include different security devices (such as VPN concentrators, Radius servers, etc), different encryption algorithms, physical security options. The tools should assess the impact of such choices on throughput, cabling, cost and other affected characteristics of the system.

    The design tools should have the capability of being easily upgraded to take new technologies into account. They should be able to add the characteristics of new technologies and equipment to their functionality without having to modify the underlying models or software architecture. The tools should support open system architecture and interface standards wherever possible. For example, the tools should support importing of standard 3D models.

PHASE I: Perform the requirements analysis and preliminary design for the WLAN design tools. Document the technical approach and describe how it will satisfy DoD requirements. Demonstrate, through prototype or analysis, the feasibility of the system. Provide a report that details the concept, feasibility analysis and metrics used.

PHASE II: Develop an implementable design. Implement a working prototype. Demonstrate the utility of the tools for designing WLAN systems for DoD applications and environments. Demonstrate tradeoff analyses and automatic generation of WLAN designs for an actual DoD application/environment. Provide a final report that details the concept, metrics, estimated life-cycle costs of solution and plans for Phase III.

PHASE III: Develop commercially viable product. Develop commercialization plans and transition plans. Demonstrate the full capability of the product for WLAN design on multiple DoD applications.

DUAL USE COMMERCIALIZATON: Wireless technology represents one of the fastest growing sectors of the IT market. Wireless LANs are proliferating in almost every environment in which wired LANs can be found and are penetrating some markets that have been infeasible for wired LANs. Design tools to reduce the cost of designing WLAN solutions for a variety of environments should have broad commercial appeal. The design tools developed under this project should have appeal for a variety of commercial applications. They should be particularly appealing for commercial applications, such as hospitals, and non-DoD government applications, where security or RF emissions are of particular concern.

REFERENCES:
1) http://grouper.ieee.org/groups/802/11/
2) ANSI/IEEE Standard 802.11, 1999 Edition
3) IEEE Std 802.11a-1999 or ISO/IEC 8802-11:1999/Amd 1:2000(E)
4) IEEE Std 802.11b-1999
5) IEEE Std 802.15.1-2002
6) Draft DoD Wireless Policy (DoDD 88XX.aa, Version 4.2b, April 01, 2002)
7) ISNS PPL/QPL Test Report: Wireless Local Area Network (WLAN), August 31, 2000, SPAWAR, Rev 2.1, Integration Test Facility, SSC SD.
8) White Paper: Going Wireless, By LCDR David R. Klain, USN, 2001

KEYWORDS: Wireless, RF, Local Area Network, WLAN, LAN, Open Systems, Artificial Intelligence, Expert Systems, Genetic Algorithms, Design Tool

OSD02-WT04 **TITLE:** Self-Configuring Hub-less Wireless Network

DOD Critical Key Technology: Electronics, Networks

MAIL PROPOSAL TO: Commanding Officer
Naval Sea Systems Command
ATTN: 05R1 Richard Milligan
1333 Isaac Hull SE STOP 5172
Washington Navy Yard, DC 20376-5172

OBJECTIVE: Enable platform and facility wireless networks to self configure without requiring hubs or other infrastructure. This capability should be able to automatically adapt to changing configurations on the fly, and to automatically enable the creation of dynamic platform/structure to structure networks on an ad-hoc basis.

DESCRIPTION: TCP/IP and related routing protocols require significant resources to set up and manage. This limits the feasibility of exploiting wireless networks in situations where set-up time is minimal or non-existent, in Damage Control situations where infrastructure cannot be counted on, and in situations where the network topology may rapidly evolve. Network capabilities such as Dynamic Source Routing are emerging that will enable point to point communications using peer-to-peer multi-hop capabilities. This type of capability needs to be exploited to enable shipboard facility e.g manufacturing plant and platform e.g. shipboard networks to operate with virtually no configuration support or other technical input required. This will enable netcentric capability to migrate wherever required and whenever needed. The objective is to create self forming networks that can expand and contract on demand, extend into damaged areas with unknown infrastructure, with no/short notice to support roving patrols, and between ad-hoc elements of the platform as needed.

PHASE I: Develop enabling concepts and Phase I design, perform risk reduction through feasibility testing.

PHASE II: Optimize the Phase I design, produce, evaluate, and deliver a full-scale prototype.

PHASE III: Full-scale development testing, and improvement of Phase II prototype.

DUAL USE COMMERCIALIZATION: These technologies are possible in numerous areas ranging from police and fire applications, to large scale enterprises such as the manufacturing environment. The commercial potential of self-organizing networks is broad and potentially far greater than that of military application.

REFERENCES:
(1) DOD Overarching Wireless Policy (Draft)
(2) NAVNETCOMINST 5400.1 NMCI PDA/Wireless Policy

KEYWORDS: Wireless; TCP/IP; Network; Electronics; Hubs; Routing

OSD DEPUTY UNDER SECRETARY of DEFENSE (S&T) / DEFENSE HEALTH PROGRAM BIOMEDICAL TECHNOLOGY FOCUS 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 thirteen topics and Service Laboratory Executive Agents to manage the SBIR topics in this technology area:

- OSD02-DH01 Life Sign Decision Support Algorithms for Warfighter Physiological Status Monitoring (WPSM), Army Medical Research Acquisition Activity TATRC
- OSD02-DH02 Non-invasive, Transdermal, Near Infrared Glucose Monitor, Army Medical Research Acquisition Activity TATRC
- OSD02-DH03 Medical Modeling & Simulation - Advanced Ureteroscopy Simulation Workstation for Medical Training, Army Medical Research Acquisition Activity TATRC
- OSD02-DH04 Non-invasive Human Metabolic Status Monitor, Army Medical Research Acquisition Activity TATRC
- OSD02-DH05 Monitoring the Warfighter, Army Medical Research Acquisition Activity USARIEM
- OSD02-DH06 Computer Based Simulation Technology for Training Technical Skills in Medicine, Army Medical Research Acquisition Activity USARIEM
- OSD02-DH07 Effectively Communicating Medical Risks, Office of Naval Research
- OSD02-DH08 SOF Critical Care Medical Tools, Special Operations Command in collaboration with DARPA

- OSD02-DH09 Global treatment Protocol Course via Advanced Distributive Learning, Air Force Research Laboratory
- OSD02-DH10 Generative, knowledge-based Approaches for Rapid Development of Simulation-based Medical Training, Air Force Research Laboratory

The topics are contained on the following pages.

In addition, there are also the following Defense Health Program Information Technology Topics for Military Health System topics:

- OSD02-DH11 Cognitive Integrated Medical Data Display System, Army Research Command TATRC
- OSD02-DH12 Medical Logistics Information Data Mining for Business Intelligence, Management of Supply Chain Operations, and Early Identification of Critical Events/Conditions, Army Research Command TATRC
- OSD02-DH13 Health Information Data Mining for Early Identification of Bioterrorism, Army Research Command TATRC

Further information regarding the Information Technology topics is contained at the end of this section.

OSD02-DH01 **TITLE:** Life Sign Decision Support Algorithms for Warfighter Physiological Status Monitoring (WPSM)

DOD TECHNOLOGY AREA: Biomedical

MAIL PROPOSAL TO: US Army Medical Research Acquisition Activity
MCMR-AAA-V (Pat McAllister)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Develop computational algorithms that interpret data from a suite of wearable physiologic sensors to automatically infer a soldier's current clinical state on the battlefield. Specifically, is the individual dead, alive, or in an unknown physiologic state due to lack of information or corrupted data. These algorithms would not predict the future clinical state of a wounded soldier but rather use present signal information and the associated uncertainties to determine the most likely current state of the soldier. The set of algorithmic computational tools should (a) integrate elements of both clinical uncertainty and data imprecision derived from possible sensor/circuit faults and data transmission failure, (b) assess the reliability of the integrated circuit of sensors and devices by taking into account the probability of failure of each component as well as the probability of failure of the integrated circuit and data transmission system as a whole, and (c) be useful in evaluating various sensor system configurations by indicating how the reliability of each component affects the reliability of the overall system. The set of algorithmic computational tools should be flexible and readily applicable to different sensor and circuit configurations and clinical analysis.

This effort would be in support of Land Warrior, Objective Force Warrior, and Future Combat Systems initiatives. It expands the scope of existing decision support efforts by considering the effects of data imprecision in addition to clinical uncertainty and providing the capability to evaluate different system designs and select the one with the highest reliability.

DESCRIPTION: The WPSM will provide health and performance data to Commanders at various levels and the battalion medical staff providing support to troops using the Land Warrior System (LWS). As the first step of development, it is envisioned that the WPSM system will provide the capability to remotely determine if a wounded soldier is dead or alive. This determination will be performed through the analysis of data from a circuit of integrated physiologic sensors monitoring the soldier by a decision support system, which should incorporate as part of the decision-making process both clinical uncertainty in the presence of contradictory evidence and data uncertainty. Clinical uncertainty is a function of the number of available monitoring physiologic parameters, the presence of contradictory information from the monitored parameters, and elapsed time. Data uncertainty relates to the validity of the data received by the decision support system that could arise from failure of a sensor/circuit or transmission system, or could be initiated externally to the system, such as the dislodgment of a sensor from the soldier's body.

One method for developing a decision support system that could account for both clinical and data uncertainties, consider the temporal evolution of the clinical decision and provide a probabilistic estimate that a wounded soldier is in a given clinical state is through modified Probability Risk Assessment tools, such as event trees, decision trees, and fault trees, which have been widely applied to analyze the reliability of electrical and electromechanical systems in industrial processes. These tools would need to be modified to incorporate clinical decisions and their associated uncertainties. This approach would also allow for the assessment of the reliability of any array of networked sensors based on an entirely probabilistic approach and the determination of how the reliability of each component affects the reliability of the overall system.

Another approach involves the use of Bayesian belief networks (BBNs) and related technologies used in Decision Theory. BBNs have a probabilistic foundation and provide the mathematical formalism whereby medical judgment may be expressed as the degree of belief in an outcome given a set of observations. Employing Bayesian probabilistic theory, it is possible to represent clinical knowledge about the dependencies between variables and to propagate consistently and quantitatively the impact of evidence for diagnosing the current state of an individual. This approach enables expert judgment to formalize the extent to which the truth of statement A supports the belief in statement B and the extent to which another truth C would weaken this belief in B so that contradictory evidence can be taken into account in the decision process. BBNs would need to be modified to incorporate data uncertainty that could arise from failure of a sensor/circuit or transmission system, or could be initiated externally to the system, such as the dislodgment of a sensor from the soldier's body.

Other methods for the development of decision support systems may include expert systems with a fuzzy-logic-based inference engine and artificial neural networks, however, these methods lack a probabilistic underpinning and require large amounts of data for knowledge extraction and model development.

PHASE I: Phase I effort should develop a feasibility concept and, if possible, an early prototype of the proposed approach by applying the developed algorithms to a hypothetical suite of sensors suggested by the principal investigator that are capable of measuring, for example, heart rate, respiratory rate, body motion and body position.

Review the literature to determine the most promising methods for developing a decision support system with the aforementioned capabilities. Conceptualize and, if possible, develop an early software prototype that given a set of physiologic sensors (no more than four), the description of the arrangement of the sensors and devices of the electric circuit, and data transmission protocols, the decision support system should provide the possible clinical states of the soldier and associated probabilities in being in each state. Phase-I effort should focus on the limiting clinical outcomes, dead or alive, and should incorporate temporal reasoning that accounts for the accumulation of clinical evidence.

PHASE II: Extend the concepts developed during the Phase-I effort to account for medical conditions associated with a continuum of clinical outcomes. Thoroughly demonstrate and validate the approach through a working prototype under realist laboratory and field conditions. For this effort, the Army will make available descriptions of candidate sensors, personal area networks, and data transmission protocols for the awarded projects.

PHASE III DUAL USE APPLICATIONS: This set of computational tools will have both military and civilian applications. The advancements in telemedicine technology and Web-based monitoring of home health patients drive needs to remotely and automatically evaluate the clinical condition of patients. These tools are similar to those proposed here for military applications.

REFERENCES:
1. N. J. McCormick, Reliability and Risk Analysis, Academic Press, New York (1981).
2. P. J. Ossenbruggen, Fundamental Principles of Systems Analysis and Decision-Making, John Wiley & Sons, New York (1993).

KEYWORDS: Warfighter Physiologic Status Monitor, decision support, decision theory, probabilistic risk assessment, event trees, decision trees, Bayesian belief networks, expert systems.

OSD02-DH02 **TITLE:** Non-invasive, Transdermal, Near Infrared Glucose Monitor

DoD Technology Area: Biomedical

MAIL PROPOSAL TO: US Army Medical Research Acquisition Activity
MCMR-AAA-V (Pat McAllister)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: The objective is development and testing of a non-invasive, transdermal glucose monitor.

DESCRIPTION: Non-invasive, transdermal determination of glucose provides a useful gauge of physiological activity and health in a variety of circumstances. The normal blood glucose range is 70 to 110 mg/dL. This concentration is within the range for spectroscopic determination and also within the possible sensitivity range for NIR Spectrophotometry via reflection or transmission of thin, capillary-rich parts of the body. Actual glucose concentration in the bloodstream is affected by numerous physiologic (e.g. time of the last meal, dehydration, perspiration, hematocrit, etc) and phenotypic variation (e.g.: skin thickness, subcutaneous fat, skin pigment, etc.) that affect result interpretation. A useful monitor must provide a means of accounting for these variables in development of an appropriate monitor and in out-put interpretation.

PHASE I: Review appropriate scientific literature to determine the most current information on phenotypic and physiologic variables impacting measurement of blood glucose. Conduct research to verify the effects and the range of these effects on non-invasive NIR Spectrophotometry determination of blood glucose; determine if additional technological methodology is necessary to control and improve specificity and sensitivity of blood glucose measurement due to the impact of these variables; conceptualize and develop report software appropriate to accounting for the effect of variables on blood glucose levels, their interpretation, and the specific value of blood glucose level. Proof of concept for this research will be accomplished through the development of a non-prototype system that, at a minimum, takes into account phenotypic and physiologic variables using NIR Spectrophotometry alone or married to other appropriate technology and permits non-invasive, transdermal determination of blood glucose levels comparable to standard clinical laboratory measurements.

PHASE II: The components determined and developed in PHASE I will be further refined and individual elements will be optimized and united to form a single device. A minimum of one prototype device will be developed and tested for safe and reliable output of non-invasive, near infra-red (perhaps in conjunction with other required technology) glucose level monitoring. Software integration will provide report functions of blood glucose levels and provide for phenotypic and physiologic variables noted in phase I development. Feasibility of production of a hand-held unit will be explored and, if feasible, a prototype device will be constructed that consists of a hand-held unit of sufficient durability for use in military-type field situations.

PHASE III DUAL-USE APPLICATION: The unit, procedures, and interpretive software will be tested in clinical studies of sufficient size as to demonstrate an effective, reliable and safe system capable of producing data comparable to that using standard clinical laboratory procedures. The completed device will prove useful in a variety of clinical, therapeutic and experimental applications. The device will be capable of being integrated with other physiologic monitoring systems to provide a medical capability in the treatment and monitoring of patients in a variety of circumstances in which blood glucose levels are required.

REFERENCES:

1) Koschinsky T, Heinemann L. Sensors for glucose monitoring: technical and clinical aspects. Diabetes Metab Res Rev 2001 Mar-Apr;17(2):113-23
2) Peters-Volleberg GW, Hilbers-Modderman ES, van den Berg Jeths A. [Progress in the field of medical devices for diabetes(Article in Dutch])]. Ned Tijdschr Geneeskd 2001 Feb 17;145(7):307-10
3) Brunetti P. [Non-invasive self-monitoring of glycemia in the therapy of diabetes mellitus: hope or reality? (Article in Italian)]. Recenti Prog Med 2000 Nov;91(11):552-8
4) Heinemann L. [Continuous monitoring of blood glucose by non-invasive methods (Article in French)]. Journ Annu Diabetol Hotel Dieu 2000;:75-86

KEYWORDS: Non Invasive Glucose Monitor, Spectroscopy, Transdermal, Glucose Level, Near Infra.

OSD02-DH03 **TITLE:** Advanced Ureteroscopy Simulation Workstation for Medical Training

DoD TECHNOLOGY AREA: Biomedical

MAIL PROPOSAL TO: US Army Medical Research Acquisition Activity
MCMR-AAA-V (Pat McAllister)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: To develop a proof-of-concept, design, develop, build and demonstrate a Personal Computer (PC)-based ureteroscopic endoscopic surgical simulation training system for training of military and civilian health care professionals.

DESCRIPTION: This effort involves demonstrating the feasibility concept and exploration of minimally invasive procedural simulation technologies that may help to improve medical training in both the government and private sectors by developing a medical simulation training system for health care professionals. This topic falls into a category of “virtual workbench”, “part-task” simulators. In a “part-task” simulation, rather than simulate an entire mission or procedure from start to finish, certain part(s) of a mission / procedure are simulated, e.g., those that are most difficult, most dangerous, least-encountered, highest-risk, etc. The system should promote the acquisition and maintenance of skills in this and other minimally invasive surgical techniques and provide a level of training not possible using the traditional medical training methods currently in use.

PHASE I: Phase I will address develop a feasibility concept and plan for developing and / or applying various innovative simulation technologies to the field of endoscopic surgery.

The following performance objectives should be met:

1. Simulator should provide visual and tactile feedback consistent with the insertion and visualization of the urinary tract in an adult patient, including the calyx of the kidney. Better methods for photo-realistic texture mapping to minimize graphic “seam” artifacts should be explored.
2. Techniques for simulation of physiological events should be explored. Integrate realistic modeling of local tissue surface deformation.
3. Realistic endoscopic lighting simulation should be explored to simulate moist tissue surface and resulting endoscopic lighting effects.
4. Real-time collision processing should be explored to detect local collisions with instruments in the working channel of the scope.
5. Representations of the physics of a flexible endoscope for real-time simulation with tactile feedback should be investigated.
6. Integrate a computer-based geometric model of the urinary tract.
7. Integrate the physics processing, device tracking, multimedia, and graphics rendering that will be applicable to all complex real-time environments.
8. Include fluoroscopic and 3-D transparent views for demonstrating real-time position of the ureteroscope. Techniques to eliminate or at least minimize the on-screen appearance of fluoroscope “flutter” should be explored.

9. Of particular interest are technologies and techniques that present the user with multiple patient conditions and complications that might be encountered during the procedure.

10. Of particular interest are technologies and techniques that allow the user to “treat” the condition presented by the simulation. Treatment should be based on clinical protocols developed and accepted by credentialed urologists in the U.S. Examples of treatment: wire and basket, laser, and lithotripter.

11. Cases and treatment should be based on embedded metrics for performance assessment and training.

12. User interface should contain a module that allows the teaching, rehearsal, testing and results tracking of the user.

13. Didactic content should encompass peri-procedural aspects of ureteroscopy, including patient preparation, local or general anesthesia, indications and contraindications and patient recovery and follow-up.

PHASE II: Develop and demonstrate a working functional prototype of the ureteroscopic endoscopic surgical simulator. The interface platform will enable the integration of individual patient cases and therapeutic treatment. The simulation should include approximately six patient cases presenting an array of complications associated with ureteroscopy.

PHASE III DUAL USE APPLICATIONS: The focus will be on commercializing a ureteroscopic endoscopic surgical simulation training system that is fieldable in both the military and civilian arenas.

REFERENCES:

1. Satava, Richard M., MD, Editor (1998), Cybersurgery: Advanced Technologies for Surgical Practice.” New York, John Wiley & Sons.
2. Operational Capability Elements: Joint Medical Readiness,” p. 6 (section 3.2.1), Joint Science and Technology Plan for Telemedicine (submitted to and approved by the DDR&E, 1 Oct 97) – available at: http://www.dod-telemedicine.org/library/papers/jstp/tmedplan.doc

KEYWORDS: Modeling, simulation, surgical metrics, medical skills training, diagnostic and therapeutic ureteroscopy.

OSD02-DH04 **Title:** Non-invasive Human Metabolic Status Monitor

DoD TECHNOLOGY AREA: Biomedical

MAIL PROPOSAL TO: US Army Medical Research Acquisition Activity
MCMR-AAA-V (Pat McAllister)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Develop and build a small, lightweight device to monitor metabolic status for optimization of human performance. Specifically, this device will rapidly and non-invasively detect the early onset of ketosis. This capability will provide the warfighter with a valuable tool to manage carbohydrate intake and ensuring peak mental and physical performance during periods of food restriction.

DESCRIPTION: Technologies are needed to detect inadequate nutritional status of soldiers working in field environments. Deployed soldiers, operating under austere field conditions, commonly have high rates of energy expenditure, carry limited food, and often don’t have and/or eat sufficient food carbohydrates to meet metabolic requirements. A portable metabolic status monitor would provide a tool to optimize nutritional intake and performance in situations where limited food is available. There are potentially useful technologies now available but they have not been applied to real-time ambulatory metabolic status monitoring. While the concept is simple, the development of such a system is complex. Technical risk and innovative strategies are encouraged. Successful submissions will focus on one or two devices. The proposed approach should be safe, simple, produce valid and sensitive results, and require minimal logistical support. Metabolic status strategies might include methods to detect metabolic by-products in expired air, saliva, or by detection methods across the skin. The device should be small and lightweight, non-invasive, inexpensive, should have no or low power requirements, be simple to operate, and provide simple to interpret results.

PHASE I: Conduct research to develop and demonstrate the efficacy of a system design that includes specifications for low levels of ketone body detection and other metabolic sensor molecules (e.g., glucose, insulin, glycosylated hemoglobin A_{1c} fraction). The system will be original or will represent significant extensions, applications, or improvements over published system designs. Provide quantitative scientific basis for chosen approach(es) based on an understanding of existing technologies and literature. Experimentation must show the strategy meets the above mentioned characteristics. Proof of concept will be demonstrated through successful development of at least one strategy, which adequately detect fat predominant metabolism as reflected by depressed respiratory exchange ratios and elevated blood ketone levels.

PHASE II: Validate and refine phase I developed strategies. Develop and demonstrate a prototype system in a realistic environment, acceptable to the United States Army Research Institute of Environmental Medicine. Provide bench test data demonstrating device durability, functionality and sensitivity. Develop additional strategies, as necessary, to further refine/augment phase I research efforts. Coordinate with the U.S. Army Research Institute of Environmental Medicine, Natick, MA to collect experimental data to confirm functionality. This phase should culminate in a detailed specification and demonstration of prototype system(s) that meet criteria stated above.

PHASE III DUAL USE APPLICATIONS: This phase focuses on producing non-invasive metabolic status systems to the specification established in Phase II effort and performing tests needed for military and commercial approval. Integrate phase II efforts with existing metabolic monitoring strategies to develop an overall support system and determine future applications. The ultimate goal is to develop an effective and simple to use technology that meets the need of the military and clinical populations where metabolic monitoring is desired. This device could be used in a broad range of military and civilian applications where nutritional support may be insufficient to match metabolic demand – for example, in third world relief operations, in clinical situations where the patient is unable to eat adequate food, and populations suffering from metabolic diseases (e.g., diabetes) that require metabolic status monitoring and early warning detection capabilities.

REFERENCES:

1) Committee on Military Nutrition Research. Not Eating Enough. B.M. Marriott (Ed.) National Academy Press: Washington, DC 1995.
2) Friedl, K.E., R.J. Moore, R.W. Hoyt, et. al., Endocrine markers of semistarvation in healthy lean men in a multistressor environment. J. Appl. Physiol. 88: 1820-1830, 2000.

KEYWORDS: metabolic sensors, nutrition, metabolism, ketosis, glucose

OSD02-DH05 **TITLE:** Monitoring the Warfighter

DoD Technology Area: Human Systems

MAIL PROPOSAL TO: US Army Medical Research Acquisition Activity
MCMR-AAA-V (Pat McAllister)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Develop a wearable computer system for the warfighter to assess cognitive performance and self-rated states (moods, symptoms, work load) in outdoor operational settings. Information can be presented to the warfighter visually (monocular display) and/or auditorily (monaurally). Data acquisition and system control are effected primarily with a speech interface with real-time, noise reduction processor. If advantageous, some self-rated questionnaires and cognitive performance tasks may be administered auditorily; in this alternate mode, the warfighter's responses (and system control) are derived from speech or a convenient manipulandum, e.g., dataglove [1].

DESCRIPTION: Recent advancements in electronics technology suggest new approaches to assessment of cognitive performance and self-rated states. The Army is currently evaluating small, portable computers (e.g., Palm and Windows CE devices), running standardized assessment software, for these assessment purposes. Historically, automated testing of cognitive performance has rarely been feasible in environments outside of the laboratory, hospital, or office. Cognitive performance is difficult to assess in outdoor, operational settings since the timeliness of a warfighter's responses to a cognitive task can be confounded by several factors inherent in the operational environment. Traditional computerized assessment devices with a display, keyboard, and "mouse" often confounded measures of timeliness because of variables such as changing levels of ambient illumination, ease of holding (and using) the keyboard and mouse, and the warfighter's posture.

This topic is for a computer system to monitor cognitive performance and self-rated states that capitalizes upon technological and human factors engineering advances evident in recent prototypes of military systems [1-3]. Such advances include standardized and validated software for assessment of cognitive performance (e.g., Automated Neuropsychological Assessment Metrics (ANAM) and Space-Flight Cognitive Assessment Tool (WinSCAT) for Windows) [4,5], a (monocular) display [3], a real-time noise reduction processor [2], wearable computer [1,3], and the use of speech as the primary interface for data acquisition and system control [1-3]. The virtual or heads-up display and speech interface for data acquisition will minimize factors that may confound measures of cognitive performance in the operational environment. A number of self-rated questionnaires and some performance tasks can be administered monaurally to reduce the warfighter's workload during assessment; the warfighter hears and responds to the prerecorded questionnaires or performance tasks being played by the wearable computer. This system also provides feedback to the warfighter about his/her cognitive performance or self-rated states.

This system is intended initially for use in military medical research programs, however, its capabilities complement and extend objectives for the Warfighter Physiological Status Monitoring System [6], e.g., assessment of the warfighter's cognitive state while on sentry duty or during a fatiguing tactical operation. This assessment system also has potential for monitoring personnel during spaceflight or in other situations, e.g., long distance aircrews, personnel in hazardous environments, monitoring patients who are physically incapacitated. Knowledge and insights into technological and human factors issues will be essential in transferring these technologies to other military and consumer applications.

This topic should result in a computerized cognitive assessment system for the military that is useable in a variety of environments and operations, e.g., warfighter in tactical environment, sentry duty, duty fitness evaluation, evaluation of the performance effects of dehydration, fatigue, operational stress, or extreme environmental conditions.

PHASE I: This phase carefully tests the technical feasibility and commercial merits of this topic. Expert staff and the necessary equipment (e.g., wearable computer, virtual or heads-up display, speech interface, and noise reduction processor) should be available for instructive prototyping and to evaluate preliminarily the five criteria described in Phase II. The Government can provide the ANAM software to the contractor, or contractor can utilize similar or equivalent cognitive performance assessment software. Human factors and user acceptability issues must be adequately addressed in the tentative systems design and integration if this SBIR topic is to transition into Phase II.

PHASE II: The primary goal is to create a reasonably rugged, prototype that demonstrates: (1) The voice data acquisition and voice control systems work well in ambient noise < 90 db, SPL. (2) The visibility and brightness of the display is not appreciably affected by dusk, bright sunlight, or normal office illumination. (3) Speech is an acceptable, primary medium for data acquisition and to control this system. (4) A convenient alternative manipulandum is incorporated into the system, and (5) Human factors issues (e.g., usability, acceptability, and wear ability) of this system are adequately addressed. After this demonstration, the system will be reviewed and evaluated on three separate occasions by the developers and proponents from Medical Research and Materiel Command. Proposed refinements and adaptations, if technically and fiscally feasible, will be incorporated into an enhanced prototype system. Twelve copies of the latest version of the complete system (with documentation and instructions) will be delivered to the proponent for research applications. The Govt. will provide test volunteers to evaluate the system's capabilities during the three review and evaluations. The Govt. will not provide the system hardware components for development or demonstration.

PHASE III (POTENTIAL COMMERCIALIZATION) A few primary commercial application of this system include utility as a portable cognitive performance assessment system in a hospital for patients with restricted mobility (i.e. bed bound spinal cord injured, head injured, ICU patients, geriatric patients), and as a remote site fit-for-duty (fatigue assessment/alcohol or other cognitive impairment) assessment tool for construction workers, truck drivers, firefighters, deep sea divers, long distance aircrews or ship pilots, space-walking astronauts, etc.

Secondary benefits include technologies that solve some of the computer system controls other than a keyboard or mouse. The motorcycle police application [1,3] such as facial recognition of a suspect or vehicle identification by having a heads-up display computer search capability. Technology exists so that it is possible to construct images of buildings, or maps of a city, from preprogrammed or satellite (GPS) images. Firefighters, emergency crews, and security forces could quickly find an emergency point with the details of city streets, building location, floor plan, etc. with preprogrammed references to hazards, threats, and risks.

REFERENCES:
1. Maxwell, J., Lathan, C.E., & Sampson, J. Development of a gesture-based interface for mobile computing. Proceedings of Human-Computer Interaction (HCL) Conference, 5-10 August 2001, New Orleans, LA.
2. Tirabassi B, A Transducer/Equipment System for Capturing Speech and Telemedicine Information for Subsequent Processing by Computer Systems. US Army Medical Research and Materiel Command. 1997. AD ADB 224296.
3. Warrick, T. Soldiers Test Digital MP System. Army News Service, 13 Nov 2001.
4. Kane RL, Kay GG. Computerized assessment in neuropsychology. Neuropsychol Rev 1992, 3:45-55.
5. Banderet, L.E., Muza, S.R., & Kane, R.L. Cognitive performance, adverse moods, and symptoms following ascent to 4300 m simulated altitude: Time courses of adverse effects. Review of Mountain Research Program at the U.S. Army Research Institute of Environmental Medicine (USARIEM) by the American Institute of Biological Sciences, 14 Nov. 2000, Natick, MA.
6. Use link on USARIEM website, http://www.usariem.army.mil/, for information regarding the Warfighter Physiological Status Monitor.

KEYWORDS: Cognitive Readiness, Virtual/Heads-up Display, Wearable Computer, Speech Technology, Self-Rated Questionnaires, Cognitive Performance, Active-Noise Reduction

OSD02-DH06 **TITLE:** Computer-based Simulation Technology for Training Technical Skills in Medicine

TECHNOLOGY AREAS: Biomedical, Human Systems

MAIL PROPOSAL TO: US Army Medical Research Acquisition Activity
MCMR-AAA-V (Pat McAllister)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: The development of a simulation-based medical training system to determine the technical feasibility of and to track user performance with computer-based simulation technology to provide initial, advanced, and refresher training of medical emergency technical skills for combat medics and other trauma care providers, such as civilian medics and emergency medical personnel, nurses and physicians.

DESCRIPTION: Currently, there is a burgeoning use of medical simulation to train first-responder military and civilian emergency personnel to respond effectively to incidents involving human injuries. The envisioned computer-based simulation training system will render a test and validation of current medical computer-based simulation trainers and evaluate the feasbility of using such training devices. As appropriate for the application, the computer system will (1) engage the user in a compelling, realistic simulation experience, (2) render functional anatomy with relevant physiologic functions, e.g., heartbeat, breathing, bleeding (3) have embedded metrics for performance assessment and tracking, (4) include case scenarios to equate training of complex clinical problems to real-life situations, (5) provide superior technology for haptics display and virtual-reality immersion, and (6) use online learning and updates, thus allowing for training and assessment from a distance. Training and certification will be consistent with those of US national registry and nurse certifying bodies as well as those of the US Army 91W Combat Medic program. Advanced Distributed Learning (ADL) features will be compatible with Shareable Content Object Reference Model (SCORM) standards. Medic training may include PC-based interactive multimedia and part-task trainers, and elements of Total Immersion Virtual Reality (TIVR). The training system will include embedded skill-assessment metrics to score technical performance. Training will be based on accurate, up-to-date information. System design will permit continuous improvement and upgrading. The system will track user performance and ensure certification.

PHASE I Objectives:
(1) Identify target audiences and develop detailed outlines of concepts that each audience must master.
(2) Propose multi-dimensional measures of competence, e.g., written tests, performance in a simulation, performance in live exercises.
(3) Model the proposed system configuration.
(4) Develop pedagogy for current and future instructional tools.
(5) Calculate system performance using current performance modeling techniques.
(6) Compare the theoretical performance of the proposed simulation-based system to actual performance of current instructional methods.
(7) Develop a design and plan to construct a prototype system.

PHASE II Objectives:
(1) Build the prototype system.
(2) Measure system performance under laboratory conditions. Compare results to current methods.
(3) Measure system performance under real-world scenarios.
(4) Determine the best approach for transition from prototype to a fieldable system configuration.

PHASE III DUAL-USE APPLICATIONS: This capability will provide an immediate, increased capability throughout military and civilian medical communities; throughout civilian law enforcement and emergency communities; and among community health-case providers such as school and community clinics. The production devices have potential widespread application to numerous medical first-responder needs.

KEYWORDS: medical simulation, advanced distributive learning, medical skills training, metrics, combat medic, trauma, emergency medical technician, performance assessment, first responder.

OSD02-DH07 **TITLE:** Effectively Communicating Medical Risks

DOD CRITICAL TECHNOLOGY: Biomedical

MAIL PROPOSAL TO: Dr. Jeannine Majde-Cottrell
Office of Naval Research
ONR 341, BCT #1
800 North Quincy Street
Arlington, VA 22217-5660

OBJECTIVE: To develop a computerized authoring tool that will assist DoD in communicating medical risks to its personnel effectively, so that their decisions will reflect objectively determined risks.

DESCRIPTION: Ever since the pioneering work of Kahneman and Tversky, we have known that risky choices can be influenced by the way in which the information about risks and probabilities is described or *framed.* Considerable research exploring these effects has been done with medical choices such as choosing to recommend or undergo risky treatments for serious medical disorders. Even though the objective data presented remain the same, it makes a big difference whether the data are presented in positive terms (likelihood of survival) or negative terms (risk of death). However, many factors in the wording of these descriptions seem to influence the size or even the existence of these effects.

PHASE I: Review the existing research literature on this topic. Determine whether the research results seem sufficiently consistent to provide the foundation for the desired authoring tool. Identify issues on which further experimentation should be done, focusing on DoD relevant applications such as vaccination programs or prophylactic medication against diseases such as malaria. Design the experiments and obtain approval for the use of human subjects in such experiments. Design and mock up or prototype the authoring tool for such communications.

PHASE II: Execute the research plan developed in Phase I and develop the communications authoring tool, modifying the design of the tool to reflect both the results of the research also to be done in Phase II and usability studies of the tool.

PHASE III: Demonstrate and market the tool for a wide variety of informed consent applications in medicine.

COMMERCIAL POTENTIAL: The need to obtain appropriately informed consent is widespread in both clinical medicine and medical research. If one could make a convincing case for the effectiveness of this communication design tool in giving people a balanced, objective understanding of the situation when they are making such decisions, the potential market could be very large. For example, recent scandals involving the use of human subjects in medical experiments have raised questions about informed consent and appropriate communication of risk. Such a tool could become a standard for assuring accurate communication of risk in such experiments. Somewhat parallel to military vaccination programs, civilian childhood vaccination programs have begun to encounter resistance. Fears that smallpox might be used to attack the general population in biological warfare have resulted in calls for renewed smallpox vaccination, although experts consider this to be a relatively high-risk vaccination. The proposed tool could be used in developing accurate communications of risk in these programs.

REFERENCES:

1) Amos Tversky & Daniel Kahneman, 1981, The framing of decisions and the psychology of choice. *Science*, 211, 453-458.

2) Amos Tversky & Daniel Kahneman, 1982, The psychology of preferences. Scientific American, 246, 160-173.

3) Chapman, G.B. & Elstein, A.S., 2000, Cognitive processes and biases in medical decision making. In: G.B. Chapman & F.A. Sonnenberg (Eds) *Decision making in health care.* New York: Cambridge University Press, pp. 183-210.

4) Hitinder, G. & Litaker, D.G., 2000, Framing procedural risks to patients: Is 99% safe the same as a risk of 1 in 100? *Academic Medicine, 75*, 840-842.

5) Rybash, J.M. & Roodin, P.A., 1989, The framing heuristic influences judgements about younger and older adults' decision to refuse medical treatment. *Applied Cognitive Psychology, 3*, 171-180.

6) Marteau, T.M., 1989, Framing of information: Its influence upon decisions of doctors and patients. *British Journal of Social Psychology, 28*, 89-94.

7) Li, S., 1998, Can the conditions governing the framing effect be determined? *Journal of Economic Psychology, 19*, 133-153.

8) Wang, X.T. & Johnston, V.S., 1995, Perceived social context and risk preference: A re-examination framing effects in a life-death decision problem. *Journal of Behavioral Decision Making, 8*, 279-293.

9) Christensen, C., Heckerling, P. et al, 1995, Pervasiveness of framing effects among physicians and medical students. *Journal of Behavioral Decision Making, 8,* 169-180.

KEYWORDS: Decision making, informed consent, medical risk, framing effects, medical communications, authoring tools, software development, cognitive psychology

OSD02-DH08 **TITLE**: SOF Critical Care Medical Tools

DOD CRITICAL TECHNOLOGY: Biomedical

MAIL PROPOSAL TO: United States Special Operations Command
Attn: SOAL-KB/SBIR Program
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621 Phone number for express packages is 813-828-6512

OBJECTIVE: Develop critical care tools to assist SOF medics and operators in saving lives during extended delays in evacuation following battlefield trauma.

DESCRIPTION: Special Operation Forces (SOF) operate in remote locations for extended periods and often with out support of conventional military medical support. SOF medics, while highly trained, are not doctors, and therefore does not have the expertise or equipment found in civilian trauma centers. SOF medics and operators urgently need two pieces of FDA approved equipment in order to provide immediate care on the battlefield during delays to evacuation; a one-handed tourniquet and an airway management device. While there are many devices on the commercial market, there are no lightweight, durable devices that provide these functions, while being usable by untrained personnel in austere, environmental unfriendly conditions.

PHASE 1: Evaluate the SOF requirement for one-handed tourniquets and airway management devices through contact with principal SOF medical personnel and evaluation of commercial items of this nature. Identify material and design technologies that can support these requirements and design required systems. Ideally, the approach would make use of existing and FDA approved devices, components, and materials. Prototype candidate designs and conducts focus groups with SOF medics.

PHASE II: Refine the design and conduct field demonstrations of prototypes. Conduct design review with FDA to assess the device's requirements for FDA approval.

PHASE III: DUAL USE OPPORTUNITIES: There are many medical emergencies where access to medical personnel and facilities will be delayed. These tools will provide hikers, boaters, aircraft personnel, offshore oil platforms, and others in remote settings with limited medical training the ability to provide some life saving medical interventions to injured personnel.

REFERENCES:
1) USSOCOM Draft Medical Modernization Plan (available from USSOCOM topic author).
2) Military Medicine Volume 161, Aug 96, Tactical Combat Casualty Care in Special Operations
3) Lessons Learned Somalia, 1993 (available from USSOCOM topic author).

OSD02-DH09 **TITLE**: Global Treatment Protocol Course via Advanced Distributive Learning

CATEGORY: Applied Research

DOD CRITICAL TECHNOLOGY: Human Systems

MAIL PROPOSAL TO: AFRL/HEOP, Ms. Sabrina Davis,
2610 7th Street, Bldg. 441, Rm 216
Wright Patterson Air Force Base, Ohio 45433
PHONE: 937.255.2423 x226; DSN785.2423 x 226

OBJECTIVE: This effort will develop a distributive and deployable training module that teaches military and counterpart civilian medical personnel an approved treatment protocol for interacting with physicians and other health care professionals.

DESCRIPTION: Telemedicine technology allows doctors and other highly trained medical professionals to participate in the initial assessment and treatment of remote patients. Treatment protocols are not standardized across the US military and civilian community causing undue hardship on both patient and medical personnel. Army, Air Force, and Navy medical personnel perform the primary assessment and treatment of patients in need of medical attention. Currently, medical personnel at all echelons lack formal protocol training for assessing patients and reporting patient conditions to physicians that would allow the latter to make the best possible patient diagnosis and direct the medical personnel to provide the best possible initial treatment until the patient can be transported to a medical facility. This reduces the quality of medical care that patients receive. The problem persists in both the combat and non-combat arena. This topic has been indorsed by the DUSD for Personnel and Readiness.

PHASE I: Leveraging the advances made through the Telemedicine and Distance Learning Initiatives this phase will develop an approved telemedicine treatment protocols. These protocols will allow all health care professionals to respond and treat using a specific set of guidelines and procedures that would be administered consistently by counterpart professionals. Currently, assessment of need, diagnostics and degree of intervention, and treatment timing of patients are not conducted on a standardized bases across the US. This lack of protocol becomes more convoluted across international barriers and linguistic differences. Subsequent to identifying the protocol structure, a training program embedded in an intelligent tutoring system so that medical personnel can receive one-on-one mentoring without the cost of an instructor will be designed. The training system will be available over the Internet so it can be accessed by military medical personnel worldwide and via a palmtop computer so that it can be used in the field as an operational aid.

PHASE II: This effort will develop an Internet/palmtop-based intelligent tutoring system that teaches medical personnel an approved telemedicine treatment protocol. The course will be tied to DOD training standards and be SCORM compliant to support ADL. There will be three major components to the technology. The first is a medical personnel management system (SMS) that keeps track of the training tasks and performance standards, the scripts contained in the training, and the medical personnel taking the training. The treatment protocol system will provide realistic continuation training.

PHASE III**:** This dual-use application will provide a cost-effective procedures and training program developed under the DOD Advanced Distributive Learning training technology requirements. This technology will provide a universal capability for medical professionals to communicate accurately regardless of language or cultural barriers. The global capability of the treatment protocols will provide a real-time access for medical professionals to review, assess, and treat patients to include those in remote environments. This global capability will integrate the standards and procedures for administering treatments to patients by military and civilian health care professionals across the world.

REFERENCES:

1) Schroeder, J. & Sorensen, H. B. (2001). *Force protection training technology using advanced distributive learning.* US Air Force Research Laboratory, Technical Report, (ARL-HE-AZ-TR-2001-0112).

2) Von Lubitz, D & Bircer, N. (2002). *Distance based medical operations and medical telepresence: new ways of doing the same old thing.* Accepted for presentation and proceedings of the 13th International Training, Education and Simulation Conference. Lille, France. April.

3) Sorensen, H.B. & Babbitt, B. (1998). Instructional decision support applied to aircrew and biomedical training. *Courseware Engineering Quarterly.* September.

4) CNN, O'Connor, E. & the Associated Press. (1999). *Medical errors kill tens of thousand annually, panel says.* Web posted, Nov. www.cnn.com/HEALTH/9911/s9/medical.errors/

5) Kohn, L., Corrigan, C.,Donaldson, M. (1999). *To err is human: building a safer health system.* Committee on Quality of Health Care In America, Institute of Medicine; National Academy Press, Washington, D. C.

6) Sorensen, H.B., Babbitt, B.A., and Katkhouda, N. (1997). *The intelligent virtual patient battlefield environment: an adaptation of a proven, rational process for the identification and training of battlefield surgical skills.* US Air Force Armstrong Laboratory, Brooks AFB, TX (AL/HR-TP-1997-011).

KEYWORDS: Advanced distributive learning, medical protocols, telemedicine, medical training, intelligent training systems

OSD02-DH10 **TITLE:** Generative, Knowledge-based Approaches for Rapid Development of Simulation-based Medical Training

DoD Technology Area: Human Systems R&D

MAIL PROPOSAL TO: AFRL/HEOP, Ms. Sabrina Davis,
2610 7th St, Bldg 441, Rm 216
Wright Patterson Air Force Base, Ohio 45433

OBJECTIVE: Develop a generative knowledge-based instructional system to rapidly produce simulation-based training for medical procedures.

DESCRIPTION: There is a prevailing need to deliver training on-demand at the operational unit to support force health protection through medical readiness training and Homeland Defense-related first response training. On-demand training can be considered training that occurs in the field to support the acquisition and retention of essential knowledge and skills in response to an imminent threat. Development of an advanced instructional system is needed to make it easy for subject matter experts to rapidly generate interactive individualized training and simulations to teach medical procedures to be distributed over the Internet. Several generative, knowledge-based and simulation-based intelligent tutoring system (ITS) techniques for instructional development and delivery have been shown to be viable approaches for rapid development of individualized, interactive multimedia courseware (ICW). Combining these approaches, a subject matter expert populates a knowledge base, using an instructional development program. The knowledge base represents the instructional content. A delivery program draws upon the knowledge base to dynamically assemble and manage instructional interactions based on the student's ongoing learning needs. Training effectiveness enhancement is expected by including development features for inserting simulations within the generative, knowledge-based framework. The courseware generated by the system should comply with requirements of the Sharable Content Object Reference Model (SCORM). To this end, the courseware would be reusable and easily modifiable, accessible to developers and students, interoperable across hardware, operating systems, and web browsers, and durable so that minimal revisions are required in response to upgrades in system software. Using this approach, an order-of-magnitude increase in development efficiency is anticipated over conventional methods for ICW and simulation development. Increases in student performance and improved retention and transfer are also anticipated. A successful approach may provide a management system for book marking and monitoring performance; a browser for guided exploration of simulations and instructional content; individualized practice exercises associated with the instructional material; capability to automatically create files that track human/computer interactions; and capability to display any type of multimedia, including immersive virtual training environments.

PHASE I: Phase I will produce a conceptual design, functional specifications, and a software development and testing plan for the instructional system. The functional specifications will include a specification for knowledge bases that would allow the system to draw upon any compliant database for its instructional content, capabilities to associate any type of multimedia with lesson content, including immersive virtual reality, and capabilities for web-based delivery.

PHASE II: Phase II will implement the software development plan from Phase I. In addition, the system will be used to develop and deliver training for medical procedures and neurological/biological/chemical response (NBCR) procedures. Studies to examine the impact of medical training on first response personnel's ability to handle various Homeland Defense-related procedures will also be conducted in this phase. Preliminary data on instructional efficiency and training effectiveness will be obtained and reported. Testing will employ representative groups of users.

PHASE III DUAL–USE COMMERCIALIZATION: The system will revolutionize the nature of interactive instruction within the Department of Defense, educational institutions, and the private sector. It has the potential for broad application to any domain where on-demand procedural training is essential, e.g., explosive ordnance unit and aircraft maintenance. It will contribute to the Government's Advanced Distributed Learning initiative by providing truly individualized instruction with powerful simulations to students for delivery anywhere, anytime. The system's potential to integrate instruction with other informational sources such as interactive electronic technical manuals could further advance training technology.

REFERENCES:

(1) Gagné, R. (1985). *The Conditions of Learning* (4th ed.). New York: Holt, Rinehart & Winston.
(2) Halff, H. M. (1993). Prospects for automating instructional design. In J. M. Spector, M. C. Polson, & D. J. Muraida (Eds.), *Automating instructional design: Concepts and issues* (pp. 67–132). Englewood Cliffs, NJ: Educational Technology Publications.
(3) Hsieh, P.Y., Halff, H.M. and Redfield, C.L. (1999). Four easy pieces: Development systems for knowledge-based generative instruction, *International Journal of Artificial Intelligence in Education. 10,* 1-45. Available http://cbl.leeds.ac.uk/ijaied/abstracts/Vol_10/hsieh.html.

(4) Kieras, D. E. (1988). What mental model should be taught: Choosing instructional content for complex engineered systems. In J. Psotka, L. D. Massy, and S. A. Mutter (Eds.), *Intelligent tutoring systems: Lessons learned* (pp. 85-112). Hillsdale, NJ: Lawrence Erlbaum Associates.
(5) Merrill, M. D. (1999). Instructional Transaction Theory (ITT): Instructional design based on knowledge objects. In Charles M. Reigeluth (Ed.). *Instructional Design Theories and Models: A New Paradigm of Instructional Technology*. Englewood Cliffs, NJ: Lawrence Erlbaum Associates.

KEYWORDS: generative knowledge-based instructional systems, intelligent tutoring systems, simulation-based training, authoring shells, procedural training, emergency medical technician and first responder training

OSD Deputy Under Secretary of Defense (S&T)/
Defense Health Program (DHP)
Information Technology Topics for Military Health System (MHS)

The Jointly Sponsored Deputy Under Secretary of Defense (S&T) and Defense Health Program Office have established this Small Business Innovative Research (SBIR) program focus area to do applied research on Information Technology (IT) issues directly supporting the Military Health System (MHS.) The MHS has approximately 80 major hospitals (Military Treatment Facilities- MTFs), 500 clinics, 160,000 healthcare personnel, and 8.3 million eligible beneficiaries. This results in approximately 900,000 outpatient visits and 10,000 admissions per week.

The objective of this solicitation is to directly support the MHS with emerging technology capture and integration. The technology research objective is to support the MHS optimization plan. The MHS Optimization Plan includes the areas of 1) access to care, 2) provision of care, 3) manage the business, and 4) population health management.

The following SBIR topics, managed by Army Medical Research Command TATRC, in this technology area are as follows:

OSD02-DH11 Cognitive Integrated Medical Data Display System
OSD02-DH12 Medical Logistics Information Data Mining for Business Intelligence, Management of Supply Chain Operations, and Early Identification of Critical Events/Conditions
OSD02-DH13 Health Information Data Mining for Early Identification of Bioterrorism

The topics are on the following pages.

OSD02-DH11 **TITLE:** Cognitive Integrated Medical Data Display System

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL PROPOSAL TO: MCMR-AT
Attn: John Winston
Building 1054, Patchel St.
Fort Detrick, Maryland 21702-5012
Phone: 301-619-7674 Email: Winston@tatrc.org

OBJECTIVES: Investigate knowledge management technologies to develop a physician and patient encounter model to provide problem-oriented user-definable information in the appropriate form and at the appropriate time.

DESCRIPTION: SBIR proposals should suggest novel ways to display complex integrated clinical data. Few military clinicians have working for them, a supporting staff member whose job focus is to gather the appropriate patient data (most recent labs graphed with previous values, pharmacy compliance data, recent radiology reports, recent ecg, recent consult report) into a packet **prior** to the appointment. Programs exist in the area of clinical trials that look for trends, graph labs with graphical representation of high and low limits and arrows/colors coded with intervention; but they have not been applied to support normal, non research oriented, clinical practice.

For a physician patient encounter, the physician user of an integrated medical information system should be able to identify the specific information needed for the encounter (problem-oriented view), but remain flexible to allow time-dependent or department (e.g., radiology or laboratory) dependent views of data. The system therefore would be a knowledge-based, concept (problem)-oriented view system, and through intelligence learns how the user follows or wants the problem-oriented views and allows modification of the views ("keyword" search for additional or modified data display) and system would generalize modification. Ideally, the system both learns a single user and a group of users, providing a default view for a new user based upon the modifications of the group. In order to be responsive, the "intelligent" user interface must also be connected to an efficient back-end processor that is able to retrieve, analyze, and format appropriate information from diverse sources, such as records of medical history and physical examinations, ancillary test results, imagery and other patient information to support a specific medical encounter. Once retrieved and processed, the information should be displayed in such a manner as to help the physician to quickly formulate or improve the physician's big-picture view (i.e., "Gestalt") of the patient within the context of specific symptoms and problems. The user interface should be web-based to support enterprise wide access to the information. Novel displays of data, using for example modified gnatt charts, graphs (for example with labs, treatment interventions, and treatment goals on a single graph), automatic calculations (of treatment efficacy (amount of decrease of BP or LDL after drug intervention), and ability to drill in from current page to additional data should be explored.

A patient has a set of ongoing, interrelated problems. When you take your car in for its 50,000 miles check up, it would be unlikely that you would return if they only performed repairs but did no maintenance. A patient should be seen as a whole, not a part isolated and out of context. Until we can present a Gestalt vision of a patient that a physician can look at a glance, technologists will be doing nothing innovative; but just presenting incomplete information within a new platform. Each medical specialty has specific packets of information they need to perform their job, but the generalist, the internist or family practice practitioner must see it all in a glance to truly manage the current problem and take care of "repairs". With each encounter the clinician should be presented with a snapshot of data related to the patient's significant and interacting medical problems so the clinician can quickly address the current problem, within the context of the whole patient and take care of maintenance simultaneously. The problem list with all integrated data is a start.

As an example, within a cardiovascular patient view, should be a chronology of interventions and findings (tabular or graphical display) of: echocardiograms (date and abnormal findings), EKGs (e.g., date and summary, linked to views), stress tests, multi-gated nuclear medicine imaging for ejection fraction and wall motion abnormalities (MUGA), blood pressures graphed with intervention/meds, coronary artery bypass surgery(s) (CABG date and vessels), abnormal physical examinations (e.g., pedal edema), and related risks (e.g. cholesterol, values graphed with intervention; diabetes mellitus (with medication list, A1C (hemoglobin marker of glucose levels); exercise program, diet consultations, alcohol and cigarette usage, medication compliance score (obtained from pharmacy record already in the ancillary clinical health care system database) and laboratory results. When each problem area of information is presented in a single screen, with an optimal single view, the clinician will immediately have a broad view of each physiological system (e.g., cardiovascular) and therefore be able to address subproblems in the context of the whole instead of just the part.

A template can work for a quick problem, but physicians do not have time to make up or remember multiple templates. In addition, data should be automatically retrieved and linked. But as always, data presentation in the traditional view must be provided for those problems that are analyzed more efficiently in traditional views.

PHASE I: This phase focuses on developing methodologies and technological concepts to enable the presentation of necessary data without negatively impacting patient/physician interactions. The researcher will do a literature search, define health information integration requirements, define and analyze technology approaches; and prepare a preliminary technical and operational design for application of candidate technologies to patient/physician interaction within the entire military continuum of care from the forward deployed to fixed medical center environments.

PHASE II: The researcher will construct a prototype system test bed and enlarge the range of existing scenarios. The prototype should demonstrate how knowledge management technologies to develop a physician and patient encounter model could provide problem-oriented user-definable information in the appropriate form and at the appropriate time to increase the quality of the physician patient interaction during medical encounters.

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) Baker DW, Parker RM, Williams MV, Pitkin K, Parikh NS, Coates W, Imara M. The health care experience of patients with low literacy. Arch Fam Med 1996; 5:329-34.

(2) Balas EA, Austin SM, Mitchell JA, Ewigman BG, Bopp KD, Brown GD. The clinical value of computerized information services. A review of 98 randomized clinical trials. Arch Fam Med 1996; 5:271-8.

(3) Blumenthal D. The future of quality measurement and management in a transforming health care system. JAMA 1997; 278:1622-5

(4) Jimison, H.B., Patient-Specific Interfaces to Health and Decision-Making Information. In: Health Promotion and Interactive Technology: Theoretical Applications and Future Directions. Street, R., Gold, M., and Manning, T., eds. 1997.

(5) Patrick K, Eng TR, Robinson TN, Gustafson D, for the Science Panel on Interactive Communication and Health. The challenge to medicine in the Information Age: The clinician's role in interactive health communication. JAMA 1998 (in press).

(6) Robinson TN, Patrick K, Eng TR, Gustafson D, for the Science Panel on Interactive Communication and Health. An evidence-based approach to interactive health communication: A challenge to medicine in the Information Age. JAMA 1998.

(7) Zeng Q, Cimino JJ. A knowledge-based Concept-Oriented View Generation System for Clinical Data. J Biomed Inform 2001 Apr: 34(2): 112-28

(8) Shahar Y, Musen MA. Knowledge-Based Temporal Abstraction in Clinical domains. 1996. Artificial Intelligence in Med: 8:267-298

KEYWORDS: Information Technology, military, Healthcare, CHCS, CHCS II, Pharmacy, Laboratory, Radiology, data presentation, patient encounter

OSD02-DH12 **TITLE:** Data Mining for Early Identification of Critical Events/Conditions in Medical Logistics

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL PROPOSAL TO: MCMR-AT
Attn: John Winston
Building 1054, Patchel St.
Fort Detrick, Maryland 21702-5012 Phone: 301-619-7674
Email: Winston@tatrc.org

OBJECTIVES: To investigate emerging technologies, methodologies, and data mining computational tools that could be leveraged for supporting transactional data research and comparative analysis on vast arrays of medical logistics/supply chain data for the purpose of improving the management of the supply chain and early identification of critical events/conditions.

DESCRIPTION: One of the primary applications would be to enable logistics researchers to use data mining tools to determine a standard methodology for monitoring and managing logistics business processes throughout the entire supply chain, and for providing early identification of critical events and conditions. In the broadest sense, data mining means looking for patterns on a collection of facts or observations. This definition includes many of the decision support tools being used today (both ad hoc and online analytical processing [OLAP] tools) to perform data mining functions. These tools query large databases to explore relationships contained in the data. The approach is to create a query or set of queries that test a hypothesis formulated by the user about patterns the data might contain. This verification-driven data mining is the cornerstone of current data warehousing applications. Verification-driven OLAP tools ease the analysis of data, but the end user is still the driver of the analysis, relied on to know what to look for in the data.

The real value in data mining lies in a more focused definition. The most exciting type of data mining is discovery-driven-- the automatic discovery of knowledge from stored data. Data mining uses sophisticated techniques and technologies (such as multivariate statistics, neural networks, and rules-based systems) that are programmed to identify patterns in the stored data. It is used to forecast the future based on a better understanding of the past, including the early detection of new trends and behavior. Data mining helps to determine what is important to measure and finds answers to questions about the business that users haven't thought to ask.
The possibilities of improving medical logistics supply chain management and effecting early identification of critical events and conditions via the use of information collected from data that are or will be in the DoD medical supply chain databases of the DMLSS system are tremendous. The Joint Medical Asset Repository (JMAR) is the existing data warehouse component of DMLSS which provides the DoD Medical Logistics community comprehensive and timely information on the location, movement, status, and identity of medical materiel (supplies, equipment, pharmaceuticals, blood and blood products) any where in the world, theater, garrison and afloat. The JMAR supports the visibility of medical logistics data across the logistics business process:

- In-Process (equipment in repair, materiel under contract, maintenance data)
- In-Storage (retail or unit, wholesale, war reserve, industry)
- In-Transit (Global Transportation Network data)
- In-Theater (pre-positioned stocks, patient movement items)

The diverse DMLSS customer base requires monitoring and decision support capabilities that go beyond simple report generation. They require granularity of information in the form of parametric and automatic indicators to identify out-of-balance conditions for proactive planning and early intervention. Information will be displayed in the form of a modern, customized desktop dashboard tool that integrates DMLSS data, producing current business intelligence and knowledge management on demand. This capability will provide business process decision-making tools to the manager without the manager having to be in an expert in all the intricacies of transactional data. Further, business intelligence must be tailorable to create the presentation layer of dashboards for the unique clinical and logistics system users.

The Data Mining tools designed or selected should utilize natural language or other artificial intelligence technique and user-friendly interfaces to eliminate any burden on the user/provider to interact with the software. The tools must be robust enough to support simple data search and retrievals as well as queries involving complex data analyses and inductive capabilities.

To date no data mining research and development has been done on the DoD medical supply chain to identify patterns in the vast amounts of stored data available and to determine the opportunity for discovery driven data mining. This is primarily because the data mining tools needed to do this research have not been designed, developed, identified, integrated nor appropriately applied to the problem; that is the focus of this SBIR topic nomination. The opportunity to detect new trends and patterns of behavior in the supply chain, forecast or predict either future supply chain requirements or critical events/conditions, and then present the data to the user in a business intelligence format tailored to their needs is the focus of this proposal.

PHASE I: This phase focuses on doing literature search, requirements refinement, scope definition, alternatives analysis and preliminary business case development. The researcher will do a literature search, define supply chain information integration requirements, define and analyze technology approaches and prepare a preliminary technical and operational design. The design will be for application of candidate data mining technologies with potential for supporting logistics business process research and comparative analysis on vast arrays of supply chain (to include financial and transportation) data within the entire military medical supply chain from manufacturer/distributor to the ultimate customer. The design will incorporate discovery-driven data mining-- the automatic discovery of knowledge from stored data using sophisticated techniques and technologies (such as multivariate statistics, neural networks, and rules-based systems) that are programmed to identify patterns in the stored data. The design will also provide for presentation of the data to the user in a business intelligence format tailored to their needs. Phase I should also demonstrate, to the maximum extent possible, proof-of-feasibility of the approach through the development of a prototype system to be expanded upon in the subsequent Phase II. The government will provide access to appropriate data.

PHASE II: The researcher would construct an expanded prototype system test bed of data mining tools and similar candidate technologies with potential for supporting supply chain business intelligence research and comparative analysis on vast arrays of transactional data within the entire military medical logistics supply chain. The tool must be robust enough to support simple data search and retrievals as well as ad-hoc queries involving complex data analyses and inductive capabilities providing users the business intelligence required for enterprise wide supply chain management. The prototype will demonstrate presentation of data to the user in a business intelligence format tailored to their needs.

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 medical logistics within civilian settings that have extensive continuum-of-care business practices resembling those of the military. These would include those enterprises such as IDNs and 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) Shaku, Atre, Defining today's data mining. Cutter Consortium 2002; Vol. 1, No. 4
(2) Geiger, Jonathan G., Data warehousing: supporting business intelligence.Cutter Consortium 2002; Vol. 1, No. 1
(3) De Ville, Barry, Integrated business intelligence for e-commerce and knowledge management. Butterworth-Heinemann; June 2001
(4) Halliman, Charles, Business Intelligence Using Smart Techniques: Environmental Scanning Using Text Mining and Competitor Analysis Using Scenarios and Manual Simulation. April 2001

KEYWORDS: Information Technology, Military, Healthcare, Data marts, Data warehouse

OSD02-DH13 **TITLE:** Health Information Data Mining for Early Identification of Bioterrorism

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL PROPOSAL TO:
MCMR-AT
Attn: John Winston
Building 1054, Patchel St.
Fort Detrick, Maryland 21702-5012
Phone: 301-619-7674
Email: Winston@tatrc.org

OBJECTIVES: To investigate technologies and methodologies and to develop approaches and computational tools for performing data mining that is capable of supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data for the purpose of identifying potential bioterrorism attacks or threats.

DESCRIPTION: One of the primary uses would be to allow healthcare researchers to perform data analysis to identify biological agent attacks on military health care beneficiary populations. Other aspects of Data Mining of the clinical data stored in the Military Health System (MHS) Data Repository (MDR) would allow for comparative results of treatment outcomes and procedures related to potential bioterrorism incidents at different health care facilities within the overall MHS systems. Algorithms could be developed to provide early detection and notification of possible biological or chemical exposures of personnel by relating observed symptoms against the time history of duty locations. The government will provide access to appropriate data.

The possibilities of improving early identification of biological attacks and subsequent medical care via the use of information collected from data that are and will be in the MHS Data Repository databases are tremendous. Data Mining on an individual's health information will allow the provider a detailed medical history, master problem analysis, drug reactions, and health care trends in a matter of seconds instead of minutes or hours if assessed from the current system of paper and electronic records. Instant aggregation and analysis of individual data on a regional military population served will facilitate early warning and decision making in regard to biological attacks.

For non-clinical information, the tools should gather, integrate, aggregate, and display staffing, financial, facility characteristics and other business data to characterize the performance of all aspects of MHS Operations related to biological terrorism preparedness. This includes integration of both direct care and purchased care. Significant increases in the scope of non-clinical data in the MDR include all staffing, manpower and personnel; facility characteristics; and data to support oversight and management of contracted Managed Care Support Contracts (MCSCs), provided by non MHS organizations. This is the business side of the fully evolved and fully populated MHS data repository.

The Data Mining tools might utilize natural language or other artificial intelligence technique and user-friendly interfaces to eliminate any burden on the user/provider to interact with the software. The tool must be robust enough to support simple data search and retrievals as well as queries involving complex data analyses and inductive capabilities.

PHASE I: This phase focuses on doing literature search, requirements refinement, scope definition, alternatives analysis and preliminary business case development. The researcher will do a literature search, define health information integration requirements, define and analyze technology approaches and prepare a preliminary technical and operational design for application of candidate data mining technologies with potential for supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data within the entire military continuum of care from the primary care outpatient clinics to the fixed medical center environments. Phase I should also demonstrate, to the maximum extent possible, proof-of-feasibility of the approach to be prototyped in the subsequent Phase II.

PHASE II: The researcher would construct a prototype system test bed of data mining tools and similar candidate technologies with potential for supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data within the entire military continuum of care that might utilize natural language or other artificial intelligence technique and user-friendly interfaces to eliminate any burden on the user/provider to interact with the software. The tool must be robust enough to support simple data search and retrievals as well as queries involving complex data analyses and inductive capabilities.

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 business practices for an extensive continuum of care that resembles 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) Ricardo Baeza-Yates and Berthier Ribeiro-Neto, Modern Information Retrieval, Addison- Wesley Longman Publishing Company, 1999.

(2) Douglas Beeferman, Lexical discovery with an enriched semantic network, In Proceedings of the ACL/COLING Workshop on Applications of WordNet in Natural Language Processing Systems, pages 358-364, 1998.

(3) Mark Derthick, John Kolojejchick, and Steven F. Roth, An interactive visualization environment for data exploration, In Proceedings of the Third Annual Conference on Knowledge Discovery and Data Mining (KDD), Newport Beach. 1997.

(4) Usama Fayyad and Ramasamy Uthurusamy, Data mining and knowledge discovery in databases, Communications of the ACM, 39(11), November 1999.

KEYWORDS: Information Technology, Military, Healthcare, Data marts, Data warehouse