ARMY

PROPOSAL SUBMITTAL

The United States Army Research Office (ARO) manages the Army's Small Business Technology Transfer (STTR) Program. The following pages list topics that have been approved for the fiscal year 2008 STTR program. Proposals addressing these areas will be accepted for consideration if they are received no later than the closing date and hour of this solicitation.

The Army anticipates funding sufficient to award one or two STTR Phase I contracts to small businesses with their partner research institutions in each topic area. Awards will be made on the basis of technical evaluations using the criteria contained in the solicitation, within the bounds of STTR funds available to the Army. If no proposals within a given area merit support relative to those in other areas, the Army will not award any contracts for that topic. Phase I contracts are limited to a maximum of $100,000 over a period not to exceed six months.

Only Government personnel will evaluate proposals with the exception of technical personnel from **Science Applications International Corporation (SAIC)** and **Azimuth, Inc**. who will provide Advisory and Assistance Services to the Army, providing technical analysis in the evaluation of proposals submitted against Army topic numbers: **A08–T035, A08–T038** and **A08–T041**. Individuals from **Science Applications International Corporation (SAIC)** and **Azimuth, Inc**. will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. These firms are expressly prohibited from competing for STTR awards and from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the source selection process, the aforementioned firm may require access to proprietary information contained in the offerors' proposals. Therefore, pursuant to FAR 9.505-4, these firms must execute an agreement that states that they will (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. These agreements will remain on file with the Army.

Please Note!

The Army requires that your entire proposal be submitted electronically through the DoD-wide SBIR/STTR Proposal Submission Website (http://www.dodsbir.net/submission). A hardcopy is NOT required. Hand or electronic signature on the proposal is also NOT required.

The DoD-wide SBIR/STTR Proposal Submission system (available at http://www.dodsbir.net/submission) will lead you through the preparation and submission of your proposal. Refer to section 3.0 at the front of this solicitation for detailed instructions on Phase I proposal format. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit. If you have not updated your commercialization information in the past year, or need to review a copy of your report, visit the DoD SBIR/STTR Proposal Submission site. Please note that improper handling of the Commercialization Report may result in the proposal being substantially delayed and that information provided may have a direct impact on the review of the proposal. Refer to section 3.5d at the front of this solicitation for detailed instructions on the Company Commercialization Report.

If you collaborate with a university, please highlight the research that they are doing and verify that the work is FUNDAMENTAL RESEARCH.

Be reminded that if your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet. Therefore, do not include proprietary or classified information in these sections. DoD will not accept classified proposals for the STTR Program. Note also that the DoD web site contains data on all DoD SBIR/STTR Phase I and II awards going back several years. This information can be viewed on the DoD SBIR/STTR Awards Search website at www.dodsbir.net/awards.

Based upon progress achieved under a Phase I contract, utilizing the criteria in Section 4.3, a firm may be invited to submit a Phase II proposal (however, Fast Track Phase II proposals do not require invitation – see Section 4.5 of this solicitation). Phase II proposals should be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000. Contract structure for the Phase II contract is at the discretion of the Army's Contracting Officer after negotiations with the small business.

The Army does not issue interim or option funding between STTR phase I and II efforts, but will provide accelerated phase II proposal evaluation and contracting for projects that qualify for fast-track status.

Army STTR Contracts may be fully funded or funded using options or incremental funding.

CONTRACTOR MANPOWER REPORTING (CMR) (Note: Applicable only to U.S. Army issued STTR contracts)

Accounting for Contract Services, otherwise known as Contractor Manpower Reporting (CMR), is a Department of Defense Business Initiative Council (BIC) sponsored program to obtain better visibility of the contractor service workforce. *This reporting requirement applies to all STTR contracts issued by an Army Contracting Office.*

Offerors are instructed to include an estimate for the cost of complying with CMR as part of the cost proposal for Phase I ($100,000 max) and Phase II ($750,000 max), under "CMR Compliance" in Other Direct Costs. This is an estimated total cost (if any) that would be incurred to comply with the CMR requirement. Only proposals that receive an award will be required to deliver CMR reporting, i.e. if the proposal is selected and an award is made, the contract will include a deliverable for CMR.

To date, there has been a wide range of estimated costs for CMR. While most final negotiated costs have been minimal, there appears to be some higher cost estimates that can often be attributed to misunderstanding the requirement. The STTR program desires for the Government to pay a fair and reasonable price. This technical analysis is intended to help determine this fair and reasonable price for CMR as it applies to STTR contracts.

- The Office of the Assistant Secretary of the Army (Manpower & Reserve Affairs) operates and maintains the secure CMR System. The CMR website is located here: https://contractormanpower.army.pentagon.mil/.

- The CMR requirement consists of the following 13 items, which are located within the contract document, the contractor's existing cost accounting system (i.e. estimated direct labor hours, estimated direct labor dollars), or obtained from the contracting officer representative:

  (1) Contracting Office, Contracting Officer, Contracting Officer's Technical Representative;

  (2) Contract number, including task and delivery order number;

  (3) Beginning and ending dates covered by reporting period;

  (4) Contractor name, address, phone number, e-mail address, identity of contractor employee entering data;

  (5) Estimated direct labor hours (including sub-contractors);

  (6) Estimated direct labor dollars paid this reporting period (including sub-contractors);

  (7) Total payments (including sub-contractors);

  (8) Predominant Federal Service Code (FSC) reflecting services provided by contractor (and separate predominant FSC for each sub-contractor if different);

  (9) Estimated data collection cost;

  (10) Organizational title associated with the Unit Identification Code (UIC) for the Army Requiring Activity (The Army Requiring Activity is responsible for providing the contractor with its UIC for the purposes of reporting this information);

(11) Locations where contractor and sub-contractors perform the work (specified by zip code in the United States and nearest city, country, when in an overseas location, using standardized nomenclature provided on website);

(12) Presence of deployment or contingency contract language; and

(13) Number of contractor and sub-contractor employees deployed in theater this reporting period (by country).

- The reporting period will be the period of performance not to exceed 12 months ending September 30 of each government fiscal year and must be reported by 31 October of each calendar year.

- According to the required CMR contract language, the contractor may use a direct XML data transfer to the Contractor Manpower Reporting System database server or fill in the fields on the Government website. The CMR website also has a no-cost CMR XML Converter Tool.

- The CMR FAQ explains that a fair and reasonable price for CMR should not exceed 20 hours per contractor. Please note that this charge is PER CONTRACTOR not PER CONTRACT, for an optional one time set up of the XML schema to upload the data to the server from the contractor's payroll systems automatically. This is not a required technical approach for compliance with this requirement, nor is it likely the most economical for small businesses. If this is the chosen approach, the CMR FAQ goes on to explain that this is a ONE TIME CHARGE, and there should be no direct charge for recurring reporting. This would exclude charging for any future Government contract or to charge against the current STTR contract if the one time set up of XML was previously funded in a prior Government contract.

- Given the small size of our STTR contracts and companies, it is our opinion that the modification of contractor payroll systems for automatic XML data transfer is not in the best interest of the Government. CMR is an annual reporting requirement that can be achieved through multiple means to include manual entry, MS Excel spreadsheet development, or use of the free Government XML converter tool. The annual reporting should take less than a few hours annually by an administrative level employee. Depending on labor rates, we would expect the total annual cost for STTR companies to not exceed $500 annually, or to be included in overhead rates.

Army STTR 08.A Topic Index

Army STTR 08.A Topic Descriptions

A08-T001 TITLE: Application of Critical Thinking to Interpersonal Interactions

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and assess a web based training system to train critical thinking skills for military interpersonal situations.

DESCRIPTION: As the scope of military operations widens to include Soldiers' interactions with personnel from other government and non-government agencies, civilians from other cultures, and coalition forces, Solders' interpersonal skills become pivotal in the success of those operations. Even within the Army itself, effective interpersonal interactions form the foundation against which successful operations are executed. For example, Army commanders must motivate, assess interpersonal situations, influence, settle disputes, negotiate, communicate, and assess and adjust the organizational climate. All of these require effective interpersonal interactions.

Interpersonal interactions are ordinarily viewed as requiring intuitive and subjective skills. However, the effectiveness of interpersonal skills would be increased by being able to deliberately and consciously think through and assess interpersonal situations, accurately assess one's own and others motivations and biases, and mindfully develop options to pursue.

Critical thinking is used in the meta-tasks of understanding, situation assessment, problem solving and decision making, and evaluating (Fischer, Spiker and Riedel, 2004). All of these tasks are also found in interpersonal situations and suggests that the use of critical thinking in these situations would contribute to increased interpersonal effectiveness.

In order to ensure that Soldiers have the best skills to operate effectively in interpersonal situations, they need to be able to apply critical thinking to those situations. The Army's educational curriculum currently includes courses in critical thinking for Army officers (e.g. Command and General Staff College Intermediate Level Education program), however those skills are applied to tasks such as mission analysis, war gaming, and analyzing courses of action, not to interpersonal situations. Explicit training applying critical thinking to military interpersonal situations is needed.

In order to develop training for critical thinking skills as applied to interpersonal skills, the relationship between critical thinking and interpersonal effectiveness should be understood. A model describing the relationship between critical thinking and interpersonal effectiveness is needed. For different types of interpersonal situations, the model would specify where in the interaction processes different critical thinking skills could be used. Further, identification of a set of high impact skills for military interpersonal situations is needed. The educational and scientific literature contains hundreds of skills that have been labeled as critical thinking skills (Fischer, et al, 2004). Those that would be most useful in military interpersonal settings should be identified.

The training development plan should include identification or development of measurement instruments to measure those critical thinking skills being trained. These measures can then be used to provide feedback to trainees and to assess the effectiveness of the training.

PHASE I: Develop a theoretical model to describe the relationship between critical thinking and effective interpersonal interactions. Identify and validate critical thinking skills applicable across a broad range of military interpersonal situations. From this set, select high impact skills for which to develop training. Develop a comprehensive training strategy for applying these critical thinking skills to military interpersonal situations.

PHASE II: Develop and assess a web based system for training critical thinking as applied to military interpersonal situations. The system would train the high impact critical thinking skills identified in Phase I. The training would be adaptable for self development, on line courses, or school house curricula. It would incorporate innovative techniques to train critical thinking skills for application in interpersonal environments within a web based training platform.

PHASE III: The model would be useful to basic research scientists in that it would articulate the relationship between critical thinking and interpersonal skills. Current literature maintains that critical thinking skills are needed in interpersonal situations but does not describe how or where they should be used. Critical thinking training is and has been of great interest to civilian and corporate educators and trainers, but the application has been to tasks not interpersonal relationships. The proposed work could extend critical thinking training to interpersonal applications in these training civilian settings.

REFERENCES:
1. Fischer, S.C., Spiker, V.A., & Riedel S.L. (2004). Critical Thinking Training for Army Officers. Volume Two: A Model of Critical thinking. Anacapa Sciences, Inc.

2. Murensky, C. L. (2000). The relationships between emotional intelligence, personality, critical thinking ability, and organizational performance at upper levels of management. Dissertation Abstracts International, 61, 1121.

KEYWORDS: Critical Thinking Skills, Interpersonal Skills, web based training, Critical Thinking Training

A08-T002 TITLE: Training Leaders to Manage Emotions in an Interpersonal Context

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a conceptual model of emotion management to guide the development of a computer-based training tool to improve leader's ability to accurately perceive and control emotions in self and others in an interpersonal context

DESCRIPTION: Strong, competent leaders define the U.S. Army of today and tomorrow. The Army leader inspires, influences, and motivates others (superiors, peers, and subordinates) both internal and external to the Army to accomplish organizational goals (FM 6-22, pp. 1-1). Leaders inspire and motivate through interpersonal communication which consists of verbal and nonverbal exchanges. Examples of interpersonal contexts in which leaders often engage include facilitating group problem solving activities, delivering performance feedback (positive and negative), and eliciting information from others. The effectiveness of the leader's exchange is dependent upon his/her interpersonal skill, particularly their tact.

A leader's level of interpersonal tact is a strong predictor of effective influence attempts. The Army defines interpersonal tact as knowing and accepting what others perceive, how they react, and the motives and values that motivate them (FM 6-22, pp. 6-3). Interpersonal tact is a combination of three leader processes: self-control (remain in control of thoughts and actions), balance (display appropriate expressions and read others' expressions), and stability (sustain appropriate expression across contexts). The effectiveness of a leader engaging with others is dependent upon his/her level of interpersonal tact, where higher levels will increase the effectiveness of leader exchange behaviors.

Underlining these leader processes are the emotions experienced by the leader and others involved in the interaction. Self-control is as apparent in a leader who controls expression of positive and/or negative emotions across all contexts. Balance refers to the leader expressing the correct emotion for a particular situation (e.g., expressing empathy towards an injured subordinate) and accurately assessing others' emotional state. Stability describes the leader's ability to maintain control of one's emotions for extended periods and across different contextual demands. Together, these emotional processes define a leader's level of interpersonal tact, and subsequently impact the leader's ability to effectively perform in an interpersonal context.

A large body of research has explored the role of emotions in interpersonal exchanges. Emotions can impact the leader's influence on team processes including promoting healthy constructive controversy (Fitness, 2000), creative problem solving (Bar-On, Handley, & Fund, 2006; Isen & Labroo, 2003), and higher performance (Jordan & Ashkanasy, 2006; Wolf et al., 2006). Leader's use of inappropriate emotions can negatively impact subordinate perceptions of the leader (Newcombe & Ashkanasy, 2002) and acceptance of feedback (Gaddis, Mumford, & Connelly, 2004). More recently, Major Abrahams investigated the role of leader emotions in an Army context with a survey of 271 U.S. Army Command and General Staff College students. Results evidenced a strong relationship between emotional intelligence and command climate, where higher emotional intelligence resulted in more reports of leaders creating effective and positive command climates (Abrahams, 2007). Taken together, these findings make it clear that emotions impact leaders' ability to engage in effective interpersonal exchanges.

The management of emotions has also been the subject of recent empirical research. Currently, management research is predominantly focused on two emotion theories: emotional intelligence and emotional regulation. Emotional intelligence (EI) consists of four distinct processes that uniquely contribute to one's level of EI. The four processes are a) the accurate perception and expression of emotions, b) assimilation or the generation of emotions to assist in problem solving, c) the acquisition of emotional knowledge to stimulate growth/development, and d) the regulation of emotions in self and others (Mayer & Salovey, 1997). This EI model prescribes a two step training process. First, individuals assess their EI ability with the Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT), which is a multi-item paper-pencil test. Second, feedback is constructed based on one's MSCEIT score and delivered by a professional with recommended training. However, the training has received limited empirical support and samples typically suffer from range restriction. Additionally, the training process is time and resource intensive.

Emotion regulation is the second approach that has recently gained momentum in the emotion management literature. According to Gross (2007), emotion regulation entails a set of processes employed to regulate intrinsic (i.e., within self) and extrinsic (i.e., within others) emotions with the goal to manage physiological commitments of emotional arousal (e.g., reducing stress levels in key situations) and emotion-related behavior (e.g., preventing maladaptive behavior in social contexts) (Eisenburg, 1998; Walden & Smith, 1997). This approach has two core aspects. First, regulation can include both negative and positive emotions. Second, regulatory processes can be both conscious and unconscious. Current regulation approaches include both cognitive (e.g., reframing the situation) and behavioral (e.g., deep, deliberate breathing) methods. The methods have shown various degrees of effectiveness. However, the literature is sparse on empirical research looking at the impact of context and stimulus on the effectiveness of a particular approach. Further, some researchers contend that that not all approaches are necessarily adaptive, which suggests the importance of considering both short-term and long-term effects prior to engaging in a regulatory process.

The current emotion management literature does not clarify which approach is best for managing emotions. First, each model describes different processes that an individual uses to manage emotions. However, the different processes appear to have some overlap with one another, which suggests an overarching model may exist. Second, the literature does not provide strong empirical evidence regarding the effectiveness of a particular approach under different contexts and stimulus. Third, it is unclear what impact the instructional format (i.e., the presentation/organizational of information and medium to delivery material) has on learning. Taken together, the emotion management field would benefit from an overarching model that would guide empirical research and instructional development.

This topic is to solicit the development of a conceptual model of emotion management. The model will drive the creation of a multi-faceted emotion management training tool to train Army leaders on emotional skills needed in order to recognize and control self and others' emotions in an interpersonal context. Development of the conceptual model will be guided by existing literature, which will provide the theoretical foundation of the training curriculum and medium. This training package will provide Army leaders with the necessary knowledge and skills to be able to effectively manage emotions of all participants during an interpersonal exchange. All training software/systems must be ADL/SCORM compliant.

PHASE I: The objective of Phase I is to develop the conceptual model of emotion management. The contractor should determine the key processes including knowledge and skills for emotion management as it relates to an interpersonal context. Development of the model should be derived from existing theoretical-based and empirical-based literature. In addition, the contractor will identify current training programs including organization of information and presentation medium.

PHASE II: Develop and validate an interactive, computer-based training tool to increase leaders' emotion management skills in an interpersonal context. Training should include interpersonal exchange scenarios in which leaders learn and develop emotion management skills while interacting with subordinates, peers, and superiors. Training must comply with Sharable Content Object Reference Model (SCORM) standards.

PHASE III: Modifications to the leader emotion management module would result in a training system applicable to leader interpersonal contexts outside the U.S. Army (e.g., joint agency endeavors). This training could be marketed in a variety of military and civilian contexts in which individuals must routinely engage in interpersonal contexts in an effort to achieve organizational goals. This training could serve as a complement to current leader knowledge and skill training taught at U.S. Army Command and General Staff College and other military education institutions.

REFERENCES:
1. Abrahams, D. S. (2007). Emotional intelligence and army leadership: Give it to me straight! Military Review, 2, 86-93.

2. Bar-On, R., Handley, R., & Fund, S. (2006). The impact of emotional intelligence on performance. In V. U. Druskat, F. Sala, & G. Mount (Eds.), Linking emotional intelligence and performance at work: Current research evidence with individuals and groups (pp. 3-21). Mahwah, NJ: Lawrence Erlbaum Associates.

3. Department of Army, Headquarters (2006). Field Manual 6-22: Army leadership. Washington, D.C.

4. Eisenberg, N. (1998). Introduction. In N. Eisenberg (Ed.), Social, emotional, and personality development (pp. 1-24). New York City, NY: Wiley Press.

5. Fitness, J. (2000). Anger in the workplace: An emotion script approach to anger episodes between workers and their superiors, co-workers, and subordinates. Journal of Organizational Behavior, 21, 147-162.

6. Gaddis, B., Connelly, S., & Mumford, M. (2004). Failure feedback as an affective event: Influences of leader affect on subordinate attitudes and performance. Leadership Quarterly, 15(5), 663-686.

7. Gross, J. J. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), Handbook of Emotion Regulation (pp. 3-26). New York City, NY: Guilford Press.

8. Isen, A. M. & Labroo, A. A. (2003). Some Ways in Which Positive Affect Facilitates Decision Making and Judgment. In S. Schneider & J. Shanteau (Eds.), Emerging Perspectives on Judgment and Decision Research (pp. 365-393). New York City: NY, Cambridge Press.

9. Jordan, P., & Ashkanasy, N. (2006). Emotional intelligence, emotional self-awareness, and team effectiveness. In V. U. Druskat, F. Sala, & G. Mount (Eds.), Linking emotional intelligence and performance at work: Current research evidence with individuals and groups (pp. 145-164). Mahwah, NJ: Lawrence Erlbaum Associates.

10. Mayer, J. D., & Salovey, P. (1997). What is emotional intelligence? In P. Salovey & D.J. Sluyter (Eds.) Emotional Development and Emotional Intelligence (pp. 3-31). New York: Basic Books.

11. Newcombe, M. J., & Ashkanasy, N. M. (2002). The role of affect and affective congruence in perceptions of leaders: An experimental study. Leadership Quarterly, 13(5), 601-614.

12. Walden, T. A., & Smith, M. C. (1997). Emotion regulation. Motivation, 21, 7-25.

13. Wolf, S. B., Druskat, V. U., Koman, E. S., & Messer, T. E. (2006). The link between group emotional competence and group effectiveness. In V. U. Druskat, F. Sala, & G. Mount (Eds.), Linking emotional intelligence and performance at work: Current research evidence with individuals and groups (pp. 223-242). Mahwah, NJ: Lawrence Erlbaum Associates.

KEYWORDS: emotional processes, emotion regulation, leader influence, interpersonal exchanges

A08-T003 TITLE: <u>Training Tools to Improve the Teaching and Coaching Skills of Military Advisors</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and evaluate an innovative training system for improving military advisors' ability to teach and coach their host nation counterparts from a different country. The training must be grounded in a theoretical framework that identifies the cross-cultural variables that impact the effectiveness of different advisor instructional approaches, as well as the cultural variables that influence host nation counterpart learning strategies and motivation.

DESCRIPTION: Recently, conventional Soldiers have had to assume the unconventional role of advisor and trainer to Iraqi and Afghan security forces. According to the 2006 Quadrennial Defense Review and supporting documents, military advisor teams and transition teams will play a larger role in all future military operations. To aid the development of these new advisor roles, the Joint Center for International Security Force Assistance (JCISFA) was established in 2006 to institutionalize best practices related to security force assistance missions. JCISFA requested the Army Research Institute for the Behavioral and Social Sciences' (ARI) assistance in exploring new and innovative methods for training military advisors so that they can more effectively teach and coach their cross-cultural counterparts and units.

Military doctrine currently provides guidance on various methods to train host-nation security forces. Advisors assist their counterparts through formal schooling, mobile training teams, and partnership teams along with advisor teams (FM 3-24, 2007). Despite the importance of the advisor team mission, the current state of the art in training advisors primarily consists of classroom lectures using PowerPoint and limited opportunities for face-to-face role playing exercises. While this training is helpful to advisors, it is insufficient for fully preparing military advisors for their advising mission, primarily because the ways in which Westerners teach individuals from a Western culture may or may not be suited to the ways in which Westerners should teach their counterparts from the Middle East. A growing body of literature on culture and cross-cultural interactions strongly suggests that substantive cultural differences exist with respect to how individuals from different countries interpret and interact with their environment. Thus, to apply Western instructional approaches in the advisement and training of host nation counterparts may be misinformed or ill-advised. For example, the Cultural Lens Model suggests that individuals from different cultures are cognitively different, and these cognitive differences have implications for training (Klein, 2004). As another example, Gelfand, Erez, and Aycan (2007) noted that there are differences among cultures with respect to expectations of how feedback should be delivered and how different types of feedback are received. This suggests that, to be effective, advisors must be trained in how to best deliver feedback to their counterparts according to the counterparts' cultural norms, not according to US standards. Gelfand et al. (2007) also noted that different cultures differ with respect to what is viewed as rewarding, suggesting that, in order to maintain sufficient motivation levels of their counterparts, advisors need to be able to ascertain what incentives are viewed as valuable in their host nation's culture.

In both the military and the private sector, little focus has been placed on the instructional and learning differences that influence how one can best train an individual from another culture. To address this problem, the U.S. school system is beginning to make changes regarding cross-cultural instruction. Notably, certain states have begun to require teacher certifications and course work in multicultural education in order to improve the instruction of intercultural students (Cushner, K. 1994; Morrier, Irving, Dandy, Dmitriyev, & Ukeje, 2007). The military must begin to adopt this perspective, as well and train the U.S. trainers (i.e., advisors) on how to most effectively train their counterparts.

Before U.S. advisor training can be developed, however, a cross-cultural theoretical model must be developed that explicates the individual advisor differences, the individual counterpart differences, the situational factors, and cultural factors that impact both how advisors should teach/coach counterparts and the learning strategies and motivation levels of counterparts. Particular focus should be on Middle Eastern cultures, drawing from reports coming out of Iraq and Afghanistan, as well as the growing body of empirical findings in the cross-cultural and multinational literatures. Because such a model does not currently exist, the development of this model would advance scientific and military understanding of cross-cultural factors in training and advising, and the application of this knowledge to training would represent cutting edge work in multinational training.

The objective of the advisor training is to provide U.S. advisors with effective instructional strategies to use with individuals from another culture, specifically those from the Middle East. Attention must be paid to language differences and communication difficulties within this setting. Although pioneering training solutions are encouraged, the training approach should conform to Department of Defense and Army standards for training.

PHASE I: Develop a theoretical model that identifies the individual advisor differences, the individual counterpart differences, the situational factors, and cultural factors that impact both how advisors should teach/coach counterparts and the learning strategies and motivation levels of counterparts. The theoretical model should lead to the identification of best practices for instruction; to relate those practices to learning theory; to develop a model that accounts for the success or failure of coaching strategies; and to describe learning style differences in a specific Middle Eastern culture. Recommendations should also be made for overcoming language and communication difficulties.

PHASE II: Offerors will develop and validate an innovative training program to improve the teaching and coaching skills of military advisors, taking into account cross-cultural differences in instructional methods, learning styles and communication difficulties. This topic encourages state-of-the-science approaches to training. However, training products should conform to the relevant Army regulations and Department of Defense guidance that guide the particular training approach proposed (e.g., TRADOC regulation 350-70, Sharable Content Object Reference Model/SCORM compliance, Section 508 compliance).

PHASE III DUAL USE APPLICATIONS: This training could be marketed and used in a variety of military and civilian applications in which individuals are required to interact and train cross-cultural groups. The theoretical model and practices derived from the theoretical model would be highly useful and marketable to organizations who engage in multinational training and global business endeavors.

REFERENCES:
1. Advanced Distributed Learning: SCORM. http://www.adlnet.gov/ and http://www.adlnet.gov/scorm/index.aspx accessed 6 June 2007.

2. Cushner, K. (1994). Preparing teachers for an intercultural context. In R. W. Brislin & T. Yoshida (Eds.), Improving intercultural interactions: Modules for cross-cultural training programs. Multicultural aspects of counseling. Series 3 (pp. 109-128). Thousand Oaks, CA: Sage Publications.

3. Department of the Army. (2006).Counterinsurgency (Field Manual 3-24). Washington, DC: Author.

4. Department of the Army. (1999). TRADOC regulation 350-70. Washington, DC: Author.

5. Gelfand, M. J., Erez, M., & Aycan, Z. (2007). Cross-cultural organizational behavior. Annual Review of Psychology, 58, 479-514.

6. Klein, H. A. (2004). Cognition in natural settings: The cultural lens model. In Michael Kaplan (Ed.) Cultural ergonomics (pp. 249-280). Amsterdam, Netherlands: Elsevier Science Publishers.

7. Morrier, M. J., Irving, M. A., Dandy, E., Dmitriyev, G. & Ukeje, I. C. (2007). Teaching and learning within and across cultures: Educator requirements across the United States. Multicultural Education, Spring, 32-40.

8. Section 508 website. http://www.section508.gov/. Accessed 6 June 2007.

KEYWORDS: teaching, instructional methods, cross-cultural, cross-cultural communication, multinational, culture

A08-T004 TITLE: <u>Field/Circuit Computational Modeling and Simulation Software Tool</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate a field/circuit computational software tool capable of modeling complete communications systems including active devices, passive devices, and antennas.

DESCRIPTION: The trend toward increasing levels of integration and miniaturization in modern military communications devices has forced the co-design of antennas and other electromagnetic elements with the baseband and drive circuitry in order to achieve first-pass design success. The circuitry can include active and passive devices with nonlinear and time-varying characteristics. The antennas and other electromagnetic elements typically are embedded in complex structures and interact with the system packaging and other electronic components. Current commercial modeling and simulation software tools cannot handle this level of complexity, although over the past ten years a number of commercial and academic research programs have made significant progress towards this goal [1-7]. Conventional time-domain techniques such as the finite-difference time-domain method show degraded spatial convergence in the presence of complex geometries due to meshing requirements, and the presence of nonlinear components further degrades performance by introducing additional time instability. Frequency-domain techniques such as the finite-element method generally suffer even greater difficulty handling nonlinear components, despite having better spatial convergence.

This topic requests the development and demonstration of a field/circuit computational software tool capable of modeling complete communications systems including active devices, passive devices, and antennas. This tool will be capable of simultaneous high-fidelity time domain modeling of the performance of radio transceivers at the circuit level including components with nonlinear and dynamic characteristics, and at the system level including time-varying antenna radiation patterns. The ability to model the effect of external electromagnetic fields on the internal operation of radio circuitry will deepen understanding of the causes of co-site interference and lead to new mitigation strategies, which in turn will improve the performance of individual communications, sensor, and EW systems operating in a common environment.

Please note that this topic explicitly does not solicit development of equivalent circuit models for simulation of electromagnetic field effects, but rather the combination of separate tools for circuit modeling and electromagnetic field simulation into a single simulation environment. Also note that this topic explicitly will not support development of a graphical user interface for problem setup and data display, and so the computational engines should be compatible with available open source GUI software [8]. The resulting software modeling and simulation tool must be verified and validated by comparison with results from analytical and other numerical techniques, and by comparison with data from a set of well-chosen experiments.

PHASE I: Develop, or identify and select, appropriate software components for circuit modeling and electromagnetic field simulation. Formulate a scheme to combine the components in order to perform the topic task. Demonstrate feasibility by generating simulation results on a simple circuit/antenna combination. Develop and deliver a constructive work plan for the development of a complete prototype commercial package in Phase II.

PHASE II: Develop and demonstrate a complete commercial prototype of the field/circuit computational software tool based on Phase I results. Verify and validate the prototype tool by comparison with results from analytical and other numerical techniques, and by comparison with data from a set of well-chosen experiments.

PHASE III DUAL USE APPLICATIONS: The technology developed under this topic will enable significant reduction in the design cycle time of Mobile Wireless Communications systems (as defined in the Army Science and Technology Master Plan) by enabling accurate prediction of radio system performance including antenna effects, and will bring similar benefit to system development for applications in commercial wireless networking and communications.

REFERENCES:
1. K. Fujimori, N. Kawashima, M. Sanagi, and S. Nogi, An efficient LE-FDTD method for the analysis of the active integrated circuit and antenna mounted non-linear devices, IEICE Transactions on Electronics, v.E90C, n.9, p.1776-1783, September 2007

2. M. Sasaki, Design of a millimeter-wave CMOS radiation oscillator with an above-chip patch antenna, IEEE Transactions on Circuits And Systems II-Express Briefs, v.53, n.10, p.1128-1132, October 2006

3. A.E. Yilmaz, J.M. Jin, and E. Michielssen, Parallel FFT accelerated transient field-circuit simulator, IEEE Transactions on Microwave Theory and Techniques, v.53, n.9, p.2851-2865, September 2005

4. H. Wu and A.C. Cangellaris, Model-order reduction of finite-element approximations of passive electromagnetic devices including lumped electrical-circuit models, IEEE Transactions on Microwave Theory and Techniques, v.52, n.9, p.2305-2313, September 2004

5. M.B. Steer, Multi physics multi scale modeling of microwave circuits and systems hybridizing circuit, electromagnetic and thermal modeling, 15th International Conference on Microwaves, Radar and Wireless Communications, MIKON-2004, v.3, p.1097-1105, May 2004

6. Xue Min Xu and Qing Huo Liu, Fast electromagnetic modeling for electronic packaging in layered media, Electrical Performance of Electronic Packaging 2001, p.181-184, October 2001

7. J.W. Schuster, R.J. Luebbers, and T.G. Livernois, Application of the recursive convolution technique to modeling lumped circuit elements in FDTD simulations, IEEE Antennas and Propagation Society International Symposium, 1998. v.4. p.1792-1795, June 1998

8. See for example GiD (http://gid.cimne.upc.es/) and the Enthought Tool Suite (http://code.enthought.com/), among others

KEYWORDS: Computational electromagnetics, circuit simulation, multi-physics modeling and simulation

A08-T005 TITLE: Trustworthy Execution of Security-Sensitive Code on Un-trusted Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this STTR is to research and develop a mechanism for trustworthy execution of security-sensitive software on un-trusted systems that may be compromised by malicious code (malware).

DESCRIPTION: Computing systems are routinely targeted by a wide variety of malwares, such as spyware, trojans, rootkits, and viruses. The presence of exploitable vulnerabilities and the availability of tools for constructing exploit code has reduced the amount of effort required for attackers to introduce malware into computing systems. Moreover, the monetary incentive motivates attackers to adopt increasingly sophisticated attack methods. The problem of intrusion by malware is further compounded by ever increasing network connectivity, which enables attacks to be launched remotely and facilitates the swift attack propagation to vulnerable computing systems. Quite often users may be unaware that their computing systems have been compromised and continue to use a wide variety of security-sensitive applications. This leads to ever increasing cases of corporate data leakage, private or personal information theft, fraud and financial losses. There is a critical requirement to develop a safe execution guarantee for security-sensitive software on un-trusted systems. The goal of this STTR is to develop new and deployable assurance technologies that can achieve the followings:
1) Assured execution of security-sensitive software:
New mechanisms must be developed to isolate the execution of security-sensitive software from all malwares that may be present on an un-trusted system. This isolation must be achieved without relying on potentially vulnerable mechanisms, such as operating system based protections.
2) Simple and transparent deployment:
The software isolation mechanisms must be easily deployable on a wide range of computing platforms, with no requirement on hardware modification.
3) Trusted verification:
There must be a simple and trusted way for the user to determine and verify that the security-sensitive software has been executed safely.

PHASE I: a. Identify and develop the techniques required to achieve isolated code execution on un-trusted systems;
b. Demonstrate the ideas by implementing a prototype system on a specific or a small subset of computing platforms.

PHASE II: a. Extend the prototype implementation on major computing systems.
b. Design and develop simple and trustworthy user notification mechanisms to indicate the safe execution of security sensitive software

PHASE III: (Dual use product development)
Un-tampered execution of security-sensitive software on a general computing platform is important for both military and commercial application. The developed technology must be converted into a product that can be used on both military and civilian computer systems. For example, the solution developed under this STTR will allow trusted online banking without worrying that the account information including username and password will be stolen by potential malicious code present on the host computer. The safe execution capability will also provide a high level of assurance to many security-sensitive DoD applications.

KEYWORDS: Safe software execution, software isolation, trusted computing platforms, defense against malicious code

A08-T006 TITLE: <u>Optimized Human Performance: Mitochondrial Energetics</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop metabolic supplements to optimize adenosine triphosphate production in eukaryotes.

DESCRIPTION: The modern Army is constrained by biology. Highly qualified and very experienced soldiers routinely leave the Army because they are old; their physical and/or cognitive performance capabilities are significantly less than that of a 20 year old. The biological basis of this reduction in performance capability may be an injury, but in most cases is simply due to the reduced efficiency of old mitochondria, resulting in reduced levels of energy (adenosine triphosphate) provided to the body to power cognitive and physical tasks. The ability to stimulate mitochondrial energy production would extend the time that soldiers remain fit for duty, boost soldier physical and performance capabilities, and expand the age range of suitable recruits. It would also eliminate the current dichotomy of the ideal soldier being optimized both for youth (high performance capabilities) and experience.

The past twenty years have seen a revolutionary breakthrough in understanding how mitochondria function. Human mitochondria are a network of approximately 2,000 proteins, exquisitely integrated into a larger network of approximately 100,000 cellular proteins, and again functionally integrated into a larger network of 3 billion cells. All of the corresponding genes have been cloned and sequenced. The biochemical basis of oxidative phosphorylation is well understood and genetic polymorphisms leading to altered energetics and performance capabilities are well documented. The scientific understanding and the technology to undertake high throughput screening to identify compounds that affect mitochondria is now possible.

PHASE I: Design, construct, and demonstrate proof of concept function for a high throughput assay to screen for compounds that increase mitochondrial copy number and/or the efficiency of mitochondrial oxidative phosphorylation. Identify libraries of compounds that will be tested in phase II. Establish a methodology for follow-up characterization of active compounds.

PHASE II: Screen libraries of compounds for stimulatory effects on mitochondrial copy number and mitochondrial oxidative phosphorylation. Characterize active compounds using genetics, genomics, bioinformatics, and biochemical approaches.

PHASE III DUAL USE COMMERCIALIZATION: The world contains approximately 4.2 billion people over the age of twenty. Even a small enhancement of cognitive capacity in these individuals would probably have an impact on the world economy rivaling that of the internet. The commercial market for a compound that could reverse the effects of aging on human energetics would be more than significant. The cost of Social Security in the U.S. is expected to approach 7% of the gross domestic product (GDP); reducing this cost by any significant degree would also have substantial impact on federal obligations and expenditures.

REFERENCES:
1. Balaban, R.S. Nemoto, S., and Finkel, T. 2005. Mitochondria, oxidants, and aging. Cell 120(4):483-95.

2. Beal, M.F. 2005. Mitochondria take center stage in aging and neurodegeneration. Ann Neurol 58(4):495-505.

3. Huang, H. and Manton, K.G. 2004. The role of oxidative damage in mitochondria during aging. Front Biosci 9:1100-17.

4. Lee, H.C. and Wei, Y.H. 1997. Role of mitochondria in human aging. J Biomed Sci 4(6):319-26.

5. Lenaz, G., Bovina, C., D'Aurelio, M., Fato, R., Formiggini, G., Genova, M.L., Giuliano, G., Merlopich, M., Paolucci, U., Castelli, G., and Ventura B. 2002. Role of mitochondria in oxidative stress and aging. Ann N Y Acad Sci 959:199-213.

6. Linford, N.J., Schriner, S.E., and Robinovitch, P.S. 2006. Oxidative damage and aging: spotlight on mitochondria. Cancer Res 1:66(5):2497-9.

7. Navarro, A., and Boveris, A. 2004. Rat brain and liver mitochondria develop oxidative stress and lose enzymatic activities on aging. Am J. Physiol Regul Integr Comp Physiol 287(5):1244-9.

KEYWORDS: mitochondria, oxidative phosphorylation

A08-T007 TITLE: <u>Liquid Metal Anodes for a JP-8 Fuel Cell</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop, characterize, evaluate, and optimize a 500 W liquid metal anode fuel cell generator utilizing electrochemical oxidation of JP-8 fuel.

DESCRIPTION: The Army has need for compact electrical generators in the 200-500 W level for use as squad-level battery chargers. The energy requirements for battery charging will require a power supply fed with an energy-dense liquid hydrocarbon fuel. Presently, methanol is the liquid fuel of choice for fuel cell power systems in this power range, but it will need to be packaged and a new logistic supply chain set in place. In contrast, JP-8 is a high-energy density liquid fuel available to the soldier, but its electrochemical oxidation in a fuel cell is problematic. Presently, there is only one fuel cell technology that has demonstrated sustainable and sulfur-tolerant electrochemical oxidation of JP-8. Tao et al (1) discuss a high-temperature (~1000 C) ceramic oxide-conducting electrolyte fuel cell that employs a novel liquid tin anode that affects electrochemical oxidation of JP-8. The liquid tin and its soluble oxides are imbibed within an inert porous separator and contacted on one face with vaporized JP-8 and on the other face with a zirconia electrolyte. An oxygen-reducing electrode adjacent the opposite side of the zirconia electrolyte completes the fuel-cell circuit. Oxides formed at the tin-electrolyte interface are transported to the fuel side of the tin layer where they oxidize the fuel with commensurate electron flow through the tin conductor to the anode current collector (hence, so-called "indirect electrochemical oxidation" of the fuel occurs). There are many variables yet to be fully explored in this approach that will effect the efficacy of the liquid-metal anode fuel cell, such as choice of liquid metal (others in addition to tin may be appropriate); liquid-metal film thickness; material and physical properties of the inert separator material (porosity, pore size, pore density, …); oxide-conducting electrolyte; air cathode; temperature, etc. The purpose of this topic is to explore the relevant parameter space and develop a sulfur-tolerant liquid-anode JP-8 fuel cell power generator based upon an understanding of the fundamental physicochemical phenomena that dictate its operation.

PHASE I: Identify and evaluate candidate liquid metal anodes for electrochemical oxidation of JP-8 in an oxide-conductor fuel cell. Characterize relevant physicochemical processes and parameters that affect the efficiency of the indirect electrochemical oxidation process. Formulate relevant mathematical models of the liquid-anode fuel cell to understand the functioning of the cell and for utilization in subsequent optimization studies. Present a conceptual study of a complete 500-W liquid-metal anode fuel cell system.

PHASE II: Design, construct, evaluate, and optimize a 500-W liquid-metal anode fuel cell generator that utilizes JP-8 directly as the fuel. An objective is to develop the most compact power generator obtainable through the liquid-metal anode technology. Deliver one complete generator to the Army for evaluation.

PHASE III: Dual Use Applications: Developments in fuel cells will have immediate impact on a wide range of military uses as well as commercial power sources such as computer power, emergency medical power supplies, recreational power, etc…

REFERENCES:

1. http://www.fuelcellseminar.com/pdf/2006/Thursday/2D/Tao_Thomas_1010_2D_618(rv2).pdf, accessed 3 Sep 2007.

KEYWORDS: Fuel cell, battery charger, liquid metal anode, JP-8

A08-T008 TITLE: Improved Physical Security of Military Bases through Perimeter Tagging

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The Objective is to develop a multifunctional spectroscopic tag that is invisible to the naked eye and can only be seen when interrogated using a man-portable infra-red (IR) viewing device. Tagging will be accomplished by the physical adsorption of a material that has the capability to significantly change an IR signature of the surface, which includes various ground surfaces, fence materials, hands and clothing. When on the ground or a physical barrier, if touched, the material will show that the area has been disturbed by interrogating its IR signature. This material will also adhere to and mark individuals who have gained unauthorized access to a facility by passing through the tagged area. This technology will increase physical security by identifying these individuals and defining their entry and exit points at a base perimeter.

DESCRIPTION: The ability to monitor the unguarded perimeter around military installations and to tag and identify individuals who have illegally entered these facilities is critical to physical security. An effective tagging strategy requires that the taggant be invisible to the naked eye, easily applied to potential entry points, such as the ground around an unguarded fence or on a physical barrier, possess suitable stability such that it lasts for months before reapplication is required, withstand outside ambient conditions, including extremes in temperature, humidity, and sunlight, covertly shows that the ground or barrier has been disturbed, and transfers to the intruder on casual contact and remains covertly attached until interrogation with a suitable device. The tag should have excellent adhesion to a variety of surfaces including various ground substances, metals, fabrics, and skin, must be safe for human exposure, environmentally benign and cost-effective. Detection of the tag requires a simple device, such as a man-portable infra-red (IR) viewer that allows detection at both close range and at a distance of 200 meters from the ground and air. This Topic may exploit advances in functional nanoparticle synthesis[1,2] to prepare materials that contain functionality that meet the criteria.

PHASE I: Research will focus on identifying materials that significantly change the IR signature[3-5] of the surface to which it has adhered when disturbed For the purposes of this Topic, material is defined as a particle, material, compound, or functionality that responds to and meets the adhesion, environmental, health, weathering, stability, and detection criteria described herein. Material lifetime and stability will be determined in environmental test chambers for evaluation with exposure to simulated weather conditions, including elevated heat, humidity and continuous UV exposure. Using a man-portable infra-red (IR) viewing device, the density of materials (g/m2) that is required to observe a significant change in the IR signature of a surface will be determined at 1, 10, 50, 100, and 200 meters. Material adhesion as well as IR signature demarcation must be demonstrated on a variety of surfaces [various ground substances (e.g., dirt, leaves, sand, gravel, rocks, pine needles), aluminum, galvanized steel, skin, and fabrics]. Research will be performed that examines tagged surfaces before and after being disturbed, and the level of taggant required to observe IR changes (i.e., g/m2 required to observe an effect). Phase I will primarily involve screening experiments designed to provide proof of concept of this approach and to identify candidate materials for down-selection and use in Phase II. Human safety and environmental impact must be addressed. A clear presentation of how the technology would work in the field must be presented.

PHASE II: Material adhesion to the substrates and transfer from one substrate to another will be quantified using statistically relevant metrology. Studies will include transfer from ground and metal (aluminum, galvanized steel) surfaces to skin and to common fabrics to determine whether the amount of taggant transferred will make a significant change in the IR signature of the affected surfaces. Also, studies should be performed that provide quantitative data to show how the IR signature changes on different tagged ground substances after being disturbed. The concentration of material will be optimized to maximize these effects and should be characterized regarding signature change as a function of distance. The best method of application of taggant material onto surfaces of interest will be determined and optimized. Conditions that deactivate, inhibit, and remove the taggant material from the surface or make it unusable should be determined and addressed. Environmental test chambers will be used to determine exposure data for taggant materials over extended periods of elevated heat, humidity, and continuous UV exposure such that realistic lifetimes and stabilities are determined for candidate materials. An integrated system will be specified that includes taggant material and a man-portable infra-red (IR) viewing device (e.g., digital camera with viewer that allows image storage of a marked individual in standard image format). Initial scale-up studies of taggant material may be performed. A model should be developed that allows the Army to understand the costs associated with this technology.

PHASE III: This technology would be of great interest to commercial shippers, security companies, police, and other institutions that require controlled access.

REFERENCES:
1. Zhang, G.; Niu, A.; Peng, S.; Jiang, M.; Tu, Y.; Li, M.; Wu, C., "Formation of Novel Polymeric Nanoparticles," Acc. Chem. Res. 2001, 34, 249-256.

2. Song, J.-S.; Tronc, F.; Winnik, M.A., "Two-Stage Dispersion Polymerization toward Monodisperse, Controlled Micrometer-Sized Copolymer Particles," J. Am. Chem. Soc. 2004, 126, 6562-6563.

3. Zhang, J.; Badger, P.D.; Geib, S.J.; Petoud, S., "Sensitization of Near-Infrared-Emitting Lanthanide Cations in Solution by Tropolonate Ligands," Angew. Chem. Int. Ed. 2005, 44, 2508-2512.

4. Langhals, H., "An Unexpectedly Simple NIR Dye for 1.1 microns with a Central Mesoionic Structure," Angew. Chem. Int. Ed. 2003, 42, 4286-4288.

5. Blake, I.M.; Rees, L.H.; Claridge, T.D.W.; Anderson, H.L., "Synthesis and Crystal Structure of a Cumulenic Quinoidal Porphyrin Dimer with Strong Electronic Absorption in the Infrared," Angew. Chem. Int. Ed. 2000, 39, 1818-1821.

KEYWORDS: tagging, tracking, spectroscopy, infrared, remote identification, physical security

A08-T009 TITLE: <u>A Nanotechnology-Based Hydrogen Generator for a Compact Fuel Cell Power System</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a compact device to produce hydrogen from the thermal decomposition of a chemical hydride that is supported on a nanostructured matrix and integrate this hydrogen generator into a soldier portable, polymer electrolyte membrane fuel cell power system. The power system must produce 20 W for 72 h with a minimum system energy density of 1 kWh/kg.

DESCRIPTION: The Army has need for high-energy, lightweight power sources for the soldier; for example, one potential scenario requires 20 W (net electric) for a three-day mission (1.5 kWh). Hydrogen-air polymer electrolyte membrane fuel cells (PEM FCs) are candidates to fill this and similar needs (1), but the source of hydrogen is problematic (2). The thermal decomposition of chemical hydrides to produce H2 is a potential solution but the rate of thermolytic decomposition is too slow and/or the temperature is too high for a soldier system (3); however, recent research (4) reports that controlling the physical/chemical environment at the nanoscale of the chemical hydride undergoing thermolysis yields improved performance in these materials. Gutoswska et al. (4) show that the chemical hydride ammonia borane is decomposed to hydrogen faster and at a lower temperature when supported on a nanoporous silica framework (SBA-15) in comparison to the unsupported (neat) material. The authors speculate that the nanostructured scaffolding of the silica affects the decomposition pathway of ammonia borane and/or the surface silanol groups of the nanosupport play a catalytic role in the hydride decomposition. The authors further hypothesize that mesoporous materials as a support, in general, may improve the kinetics and thermodynamics of hydrogen production from other chemical hydrides placed on/within them, as may have been observed by Zuttel et al. (5) in the decomposition of LiBH4 mixed with SiO2 powder. It remains unclear if the production of H2 from other (lower cost but equally H2-rich) chemical hydrides in addition to ammonia borane can be effected in a positive manner through a nanostructured support. It is also unknown if thermal management issues might arise in a H2-producing device that utilizes a supported chemical hydride. The weight and volume of the support itself lowers the energy density of the hydrogen-generator system, and it is uncertain if the target energy density for the three-day mission is obtainable. These and other issues (including cost and environmental impact) must be examined before the nanotechnology-based hydrogen generator described above can be made available for a dismounted warrior PEM fuel cell system.

PHASE I: Identify, design, construct, and evaluate at the breadboard level a hydrogen generator that utilizes the thermolytic decomposition of a chemical hydride supported on a nanostructured matrix. Demonstrate quantitatively improvements realized in hydrogen production rate, operation temperature, and reactant conversion in comparison to the unsupported hydride compound. The H2 generator must be fed with a hydride fuel packet, with each packet sufficient to support 24-h operation of a 20-W (net) PEM fuel cell power system. Control and thermal management issues and subsystems must be identified and demonstrated. Develop a conceptual design that integrates the hydrogen generator into a soldier-portable, 20-W PEM fuel cell generator.

PHASE II: Design, construct, and evaluate a compact hydride-based hydrogen generator that utilizes nanostructured-support materials for the hydride and integrate into a soldier portable 20-W (net) PEM fuel cell power system with a minimum system energy density of 1 kWh/kg for 72-h operation. One complete 20-W (net) power system for test and evaluation is to be delivered to the Army with thirty fuel packets to supply ten three-day missions.

PHASE III: Dual Use Applications: Developments in safe hydrogen sources for fuel cells will have immediate impact on a wide range of military uses as well as commercial power sources such as computer power, emergency medical power supplies, recreational power, etc…

REFERENCES:
1. A. Patel et al., "Portable fuel cell systems for America's Army: technology transition to the field," J. Power Sources, 136 (2004) 220-225.

2. N. Sifer and K. Gardner, "An analysis of hydrogen production from ammonia hydride generators for use in military fuel cell environments," J. Power Sources, 132 (2004) 135-138.

3. ARO Workshop Proceedings, "Hydrogen Storage and Generation for Medium-Power and –Energy Applications," University of South Carolina, M. Matthews, ed (1997).

4. A. Gutowska et al., "Nanoscaffold Mediates Hydrogen Release and the Reactivity of Ammonia Borane," Angew. Chem. Int. Ed., 44 (2005) 3678-3582.

5. A. Zuttel et al., J. Power Sources, 118 (2003) 1-7.

KEYWORDS: Chemical hydride, hydrogen, fuel cell, soldier power

A08-T010 TITLE: <u>A Compact Solid Acid Electrolyte Fuel Cell Generator</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a hydrocarbon-fueled solid acid electrolyte fuel cell generator that does not require water maintenance and operates at temperatures between 200 and 400 °C. The compact power system must produce 20 W (net) for 72 h with a minimum system energy density of 1 kWh/kg.

DESCRIPTION: The Army has need for high-energy density, lightweight power sources for the dismounted warrior. Hydrogen-air and direct-methanol polymer electrolyte membrane fuel cells (PEM FCs) are candidates to fill these needs, but the polymer electrolyte membrane must be hydrated for proton conductivity, which adds the complexity of a water-management subsystem to the power generator and limits the cell operation temperature to approximately 80 C or lower. Additionally, because hydrocarbon reformers produce carbon monoxide as a co-product with H2, a CO scrubber is needed so as not to poison the fuel cell's platinum electrodes, which also adds additional weight and complexity to the power generator. Higher temperature operation (> 120 C) of the cell would be advantageous in that heat-transfer characteristics of the cell stack improve and CO poisoning of the electrodes is not a concern. Certain classes of solid acids (e.g., CsHSO4 or CsH2PO4) are proton conductors that have recently been demonstrated to function as effective electrolytes at temperatures 200 C and higher (1-4), and these materials have been incorporated as combination electrolyte/separator in laboratory scale fuel cells fed by H2 or methanol (5). The long-term interfacial electrode-electrolyte impedance in these solid acid electrolyte cells is a challenge, and it is unknown if a practical fuel cell power system can be built around this intermediate-temperature class of proton conducting electrolytes. The presence of liquid water in the cell (at start-up or shut-down) may also be problematic. The elevated operation temperature of the solid acid cells, on the other hand, presents the intriguing possibility for direct electrochemical oxidation of hydrocarbons and/or in situ reforming. These and other issues must be examined to determine if a compact power system can be built around a proton-conducting electrolyte and provide the power needs for the dismounted warrior.

PHASE I: Design, construct, and evaluate a hydrocarbon-fed, bench-scale, single-cell fuel cell that utilizes a solid acid electrolyte and demonstrate a multi-cell stack based upon these results. Include all control and ancillary subsystems required to produce power from a multi-cell stack. Polarization characteristics (voltage vs current and power density) of the cell and cell stack should be reported, as well as interfacial impedance behavior of the electrolyte-electrode interface. Provide a conceptual design of a 20-W (net) power system based upon the results generated in these efforts.

PHASE II: Design, construct, and evaluate a compact 20-W generator based upon the solid acid electrolyte and hydrocarbon fuel studied in Phase I. The compact power system must produce 20 W (net) for 72 h with a minimum system energy density of 1 kWh/kg.

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

REFERENCES:
1. T. Uda et al., Solid State Ionics, 176 (2005) 127-133.

2. Chisholm et al., Physical Review B, 72 (2005) 134103-134123.

3. T. Uda and S. Haile, Electrochemical and Solid-State Letters, 8 (2005) A245- A246.

4. T. Uda et al, Electrochemical and Solid-State Letters, 9 (2006) A261-A264.

5. S. Haile et al, Faraday Discussions, 134 (2007) 17-39.

KEYWORDS: Fuel cell, proton conductor, solid acid electrolyte, soldier power

A08-T011 TITLE: <u>Active Transport Exchange for Compact Sustained Power</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To develop advanced synthetic membranes and storage systems based on the biological gill-swim bladder system and create a unique apparatus capable of gathering and storing oxygen for use in fuel cells to provide compact sustained power in either underwater or high altitude environments.

DESCRIPTION: Molecular transport mechanisms in cellular membranes, which are inherently both efficient and selective, provide tremendous motivation for utilizing these mechanisms in synthetic materials. Among the various transport mechanisms utilized by cellular membranes, active transport affords the unique capability of solute transportation against a concentration gradient. In marine biology, gills utilize hemoglobin to absorb oxygen from the water and transport it to the swim bladder for storage. This gill-swim bladder system constitutes an ideal model from which to design a novel apparatus suitable for extracting oxygen for fuel cells to provide sustained power sources in either underwater or high-altitude environments. Advances in molecular biology now provide a variety of tools capable of determining the quantitative tissue-specific and spatial distributions of the transport proteins which govern the gill-swim bladder system at the molecular scale. These tools enable robust and rapid characterization of the structure, dynamics and function of these transport systems. Furthermore, recent breakthroughs have demonstrated the ability to reconstitute biological transport proteins and to insert them into synthetic materials while retaining their functionality. Recent accomplishments in countercurrent exchange and ionic liquid separations also offer excellent potential to enable oxygen sources for compact sustained power.

What is expected from a successful effort is the creation of a compact sustained power source capable of extracting and storing oxygen directly from a marine or high altitude environment to supply a fuel cell. The use of novel synthetic membranes to facilitate active transport exchange is expected to provide the breakthrough absorption and collection properties necessary to develop a functional apparatus. Identification and design of optimal fluids to facilitate oxygen transport is expected to significantly improve design performance. Compact sustained power devices would have direct application in UUVs, UAVs, undersea distributed network systems, and even to sustained presence sensors capable of operating in a broad range of low-oxygen environments.

PHASE I: Design and demonstrate synthetic membranes and storage systems to provide optimal oxygen extraction and storage from a marine or high altitude environment. Select, fabricate, and demonstrate an optimized material solution and provide a quantitative characterization of oxygen extraction and storage capacity in marine or high altitude environments scalable to oxygen gas extraction of at least 2 mL/min/m2 filter. Develop a conceptual design for a complete power source using these results, including estimates of the capabilities and requirements of a complete system.

PHASE II: Construct a prototype design for a compact sustained power source and demonstrate the capabilities of the design in underwater, high altitude, or other low oxygen environments. Refine and optimize power and storage capacity requirements to achieve oxygen gas extraction of 4 mL/min/m2 filter.

PHASE III DUAL USE COMMERCIALIZATION: Novel oxygen extraction and storage systems will enable unique compact sustained power sources for a broad range of military and civilian use, including that by warfigthers, first responders, divers, and construction and salvage workers.

REFERENCES:
1. Randall DJ, CARDIOSCIENCE 5 (3): 167-171 SEP 1994.

2. Perry SF, et al., COMPARATIVE BIOCHEMISTRY AND PHYSIOLOGY A-MOLECULAR & INTEGRATIVE PHYSIOLOGY 129 (1): 37-47 SP. ISS. SI MAY 2001.

3. Matsuno N, et al., BIOCHIMICA ET BIOPHYSICA ACTA - BIOMEMBRANES 1665, 184-190.

4. Scovazzo P, et al., INDUSTRIAL AND ENGINEERING CHEMISTRY RESEARCH, 43, 6855-6860 (2004).

5. Gupta G, Atanassov P, et al., PROCEEDINGS OF THE POLYMERIC MATERIALS SCIENCE AND ENGINEERING DIVISION, 234TH NATIONAL MEETING OF THE AMERICAN CHEMICAL SOCIETY, BOSTON MA, AUGUST 2007.

KEYWORDS: Underwater High Altitude Oxygen Transport Sustained Power

A08-T012 TITLE: Electrostatic atomizing fuel injector for small scale engines

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Design, develop and demonstrate the feasibility of an electrostatic atomizer that will enable small scale (5hp) engines to run a spark-ignition cycle on JP-8.

DESCRIPTION: DoDD 4140.25 (1) has directed that all land based ground and air forces shall use a single fuel with JP-8 leading the order of precedence. There are several current and future military applications where a small (~5hp) spark ignition power plant is desirable, such as UAV propulsion. A high flash point fuel such as JP-8 poses several technical challenges when used in such a small engine application. One significant challenge is in achieving sufficient atomization to support a small scale spark ignition engine. Electrostatic atomization is a potential path to achieving sufficient atomization to allow low volatility fuel to be used in such small scale engines. A second challenge would be to achieve this electrostatic atomization using JP-8 fuel as specified by MIL-DTL-83133E (2), i.e. without the addition or deletion of any additives or additive packages beyond the specification. Recent studies (3) have shown that one method of electrostatic atomization, charge injection, is especially promising at promoting initial spray breakup and dispersion as well as secondary atomization (4). Further, charge injection has been shown to be able to operate under a pulsed injection scheme (5). This would enable a direct injection, non-throttled, spark ignition engine using a low-volatility fuel while enhancing engine efficiency and control.

PHASE I: Design, develop and demonstrate a electrostatic atomizer that will enable atomization of JP-8 fuel (as specified by MIL-DTL-83133E) sufficient to be used in a small scale (5hp) spark ignition engine. Deliver a plan for achieving pulsed atomization to enable Direct Injection Spark Ignition (DISI) in Phase II.

PHASE II: Design, develop and demonstrate a pulsed injection electrostatic atomizer which enables a 5hp flight-weight engine in a DISI cycle using JP-8 fuel (as specified by MIL-DTL-83133E). Deliver one system to the Army.

PHASE III Dual Use: Development of electrostatic atomization injectors to enable DISI cycle on small scale engines with low-volatility fuels (JP-8 and DF-2) will allow higher efficiency, improved emissions and increased safety for small scale engines in widespread use throughout the commercial community.

REFERENCES:

1. DoD Directive 4140.25, "DoD Management Policy for Energy Commodities and Related Services", April 12, 2004.

2. MIL-DTL-83133E, “Detail Specification – Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35, and JP-8+100,” April 1, 1999.

3. Shrimpton, J.S. and Rigit, A.R.H., (2006) Atomization and Sprays, v16 pp421-444.

4. Lehr, W. and Hiller, W. (1993) Journal of Electrostatics, v30 pp433-440.

5. Shrimpton, J.S. and Laoonual, Y., (2006) Intl J for Numerical Methods in Engineering v67 pp1063-1081.

KEYWORDS: electrostatic, spray, fuel injection, uav propulsion, pulsed injection

A08-T013 TITLE: Time–Domain Terahertz Ellipsometry for Reflection-Mode Sensing

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: The development and demonstration of a new scientific instrument – a time-domain terahertz (THz) ellipsometer – that will offer a significantly advanced (e.g., reliable and real-time) THz frequency characterization capability for object interrogation and signature acqusition in reflection geometries.

DESCRIPTION: The ubiquity of picosecond timescales in condensed matter makes measurement tools employing THz radiation potentially quite useful [1]. Unfortunately, measurements in this spectral range have been challenging to implement as they lie in the so-called ``THz gap'' - above the capabilities of traditional electronics, but below that of optical generators and detectors (photonics). In recent years there have been a number of dramatic advances in the form of time-domain THz spectroscopy, which allow measurements that span this gap and have made this an exciting and emerging area of optical and materials research. However, an outstanding technical problem has been determining complex optical constants of materials when performing measurements in reflection, thus leaving the only reliable measurements to those where the target objects/materials are transparent enough to perform transmission characterization. However, transmission measurements are not feasible for many target objects/materials and so far the technique has been difficult to apply to many metals, thick or highly doped semiconductors, coatings on opaque substrates, substances in aqueous solution, and any otherwise opaque compound. Hence, the inability to perform reliable reflection based THz measurements is significantly retarding progress in this field. This project aims to address this problem by developing a completely new spectroscopic technique that circumvents existing technical issues and allows time-domain THz measurements to be performed quickly, reproducibly, and eventually routinely in reflection.

This project seeks the development and demonstration of a THz time-domain ellipsometer that will overcome existing technical problems. Ellipsometry is a standard technique at optical frequencies for evaluating optical thin film coatings and has enabled a multi-billion dollar industry. Therefore, the application of this technique to time-domain THz spectroscopy will facilitate a completely unique measurement tool that will impact a number of research areas currently of intense interest to the military. These include measurements of the broad band response of stealth appliqués (e.g., a novel paint replacement technology) [2,3], metrology of dielectric layers buried under thin metal films, general THz-range materials characterization, meta-materials development [4], the characterization of biological specimens in aqueous solution [5], and the security domain (explosives and biohazard detection) [6,7].

As standard polarizing elements perform poorly in this spectral range, it is anticipated that use will be made of an advance in the Auston switch detectors used for time-domain THz. Specifically, it has been recently shown that 3-pole switches can be fabricated that can detect two independent polarization directions [8]. Among other aspects they will enable an ellipsometer with no moving parts. We emphasize that the goal of this program is to develop a general purpose instrument that will enable measurements previously impossible. It is anticipated that with the general utility and importance of THz radiation and the existing problems with performing THz reflection measurements, this work will lead to a whole new standard technique for performing spectroscopy in the THz spectral range and impact many areas of applied science and industry that will lead to payoffs for national defense and security such as those listed above.

PHASE I: Phase I of the program should investigate proof-of-concept spectrometer components and perform laboratory measurements that confirm the utility and effectiveness of polarization techniques in achieving THz reflection characterizations and signature acquisitions. The effort should also quantify a design for a time-domain THz ellipsometry that could be implemented under a Phase II effort.

PHASE II: In Phase II, a full prototype time-domain THz technique should be implemented and demonstrated in defense and security relevant sensing applications. Here, the technique should be used to give a full THz characterization and/or signature acquisition for an array of materials and objects. For example, the technique should be applied to such activities as: stealth coating characterization, meta-materials development, the characterization of biological material in aqueous solution, and the detection of explosives and biohazards in quasi-point and stand-off scenarios.

PHASE III: In the third phase of the project, techniques will be developed for scaling up production of the ellipsometer and for enhancing the sensitivity and lower associated costs. Also, the project will transition from applied science to manufacturing schemes that allow for wide scale commercialization while preserving the capabilities of the spectrometer. This phase will also focus on applications areas that possess the largest commerical payoff potential. Here, it is anticipated that areas such as testing for product quality assurance and threat-agent detection (e.g., chemical, biological, explosives) are potential areas of emphasis.

REFERENCES:

1. http://www.er.doe.gov/bes/reports/abstracts.html#THz

2. http://www.estcp.org/projects/pollution/199911v.cfm

3. http://www.freshpatents.com/Applique-dt20050818ptan20050181203.php

4. J. B. Pendry and D. R. Smith, Physics Today 37, (June, 2004).

5. M. Nagel, et al., Appl. Opt. 41, 2074-8 (2002).

6. K. Lewotsky, SPIE Professional April, (2006).

7. S. Wang, B. Ferguson, D. Abbott and X.-C. Zhang, J. Bio. Phys. 29, 247-256 (2004).

8. E. Castro-Camus et al., Appl. Phys. Lett. 86, 254102 (2005).

KEYWORDS: terahertz frequency, time-domain, ellisometry, reflection mode, threat-agent sensing

A08-T014 TITLE: Micro-burner Based Flame Ionization Detectors for Micro-scale Gas Chromatographs

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

OBJECTIVE: Develop and evaluate a micro-burner based flame ionization detector and integrate with a micro-scale gas chromatograph for sensing fuel composition, chemical warfare agents, and explosive vapors.

DESCRIPTION: Rapid, accurate gas sensing of vapors associated with toxic compounds of chemical warfare agents and improvised explosive devices (IEDs) is of critical importance to the Army. Portable gas-sensing devices presently exist, but their accuracy is low, where accuracy here refers to a lack of false positives. According to a recent Army Soldier and Biological Chemical Command report, GC/FPD/MS hardware provides the required accuracy and sensitivity but current devices are too heavy and consume too much power to be carried by a warfighter. The Army needs a new approach for portable gas sensors that provides real-time rapid environmental assessment for the warfighter. Micro-scale MEMS-based gas chromatographs (MEMS-GC) have recently been designed and built that can support a 7-day mission, with the size of the MEMS-GC, detectors, reagents, power supply, etc. of only a few cubic centimeters (1). To reduce false positives multiple sensing modalities are a critical need. However, most micro-sensing modalities are focused on a narrow set of compounds. To aid in sensing a spectrum of compounds, flame ionization detectors (FIDs) are advantageous (2). Unfortunately, presently available FIDs are too large and use significant quantity of fuel. There is a need for a fuel-efficient micro-scale FID that works in conjunction with a MEMS-GC to enable a compact and versatile gas-sensing apparatus. Recently, high-temperature micro-combustors that run on high-energy density fuels have been developed that can supply the required flame, temperatures, and size (3-6). These breakthroughs in micro-burners form a basis for portable, light-weight, and long-mission life gas sensors with the capability to detect and quantify a wide variety of compounds with low false positives.

PHASE I: Develop a micro-flame ionization detector (micro-FID) with critical dimensions below 1 millimeter that will work in conjunction with a MEMS-gas chromatograph. Select the most promising approaches for integration with a MEMS-GC system. Demonstrate the detection of eight-contractor specified battlefield-relevant fuel surrogates, simulants, and interferents with the micro-FID.

PHASE II: Integrate the micro-flame ionization detector, which must be less than a few cc in volume including fuel for a 7-day mission, with a MEMS-based gas chromatograph. Demonstrate that the integrated micro-FID/MEMS-GC system accurately detects and quantifies fuel components, simulant explosive and CW agents in the presence of interferents. Deliver one complete system to the Army.

PHASE III/DUAL-USE APPLICATIONS: In addition to providing fuel sensors, CW and explosive vapor sensors for the Army, private-sector commercial potential will be in the areas of propulsion system in-situ fuel assessment (flexible fuel systems), homeland security systems, environmental monitoring, and industrial gas sensing.

REFERENCES:
1. Z. Ni, M. Shannon, K. Cadwallader, J. Jerrell and R. Masel "A Metal-Organic Framework Based Preconcentrator For Gas Sampling In A Micro-Gas Chromatograph" Proceedings 9th International Conference On Miniaturized Systems For Chemistry And Life Sciences, Boston Oct 2005, 262-264.

2. Zimmermann S., Wischhusen S., and Muller J., "Micro flame ionization detector and micro flame spectrometer," Sensors and Actuators B: Chemical, V. 63 (3), 15 May 2000, 159-166.

3. Miesse, C. M., R. I. Masel, M. Short, and M. A. Shannon, "Experimental Observations of Methane-Oxygen Diffusion Flame Structure in a Sub-millimeter Microburner," Combustion Theory and Modeling, Institute of Physics Publishing, Ltd. V. 9, 2004, 1-16.

4. Miesse, C.M. R.I. Masel, M. Short, and M. A Shannon, "Experimental Observations of the Structure of a Diffusion Flame in a Sub-millimeter Microburner: Flame Cells and Other Unexpected Effects" Combustion Theory and Modeling, 9, 77-92, 2005.

5. Miesse, C.M., R.I. Masel, C.D. Jensen, M. A Shannon, and M. Short , "Sub-millimeter-scale combustion," AICHE JOURNAL 50 (12): 3206-3214 (2004).

6. Masel, R.I., Final Report: Design Rules for High Temperature Microchemical Systems, http://www.ntis.gov/search/product.asp?ABBR=ADA459407&starDB=GRAHIST, accessed 16 July 2007.

KEYWORDS: Gas-chromatograph, Sensors, Flame-ionization detectors, micro-burners

A08-T015 TITLE: Breathable Elastomer Membrane Liner

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

OBJECTIVE: Develop a lightweight chemical agent protective liner membrane for individual protective suits that provides significant evaporative cooling to prevent heat stress, while protecting the soldier from exposure to chemical warfare agents (CWAs), toxic industrial chemicals (TICs) and toxic industrial materials (TIMs).

DESCRIPTION: Current protective garments are either made from impermeable and non-breathable materials, or are made from breathable, yet heavy organic-absorbent materials. For example, butyl rubber is used to make non-permeable gloves and suits, which have excellent chemical warfare agent resistance, but is also impermeable to water vapor. Thus heat stress is a significant debilitating problem. The current solution is to employ an activated carbon / polymer liner material inside a breathable fabric, but this also adds a significant weight burden. For example, the Joint Service Lightweight Integrated Suit Technology (JSLIST) suit uses this activated carbon technology. The Joint Chemical Ensemble (JCE) intends to meet these future requirements by inserting revolutionary technologies into chemical protective ensemble solutions as those technologies mature. The ideal solution would be a lightweight membrane that is a barrier to CWAs, TICs, and TIMs, but which is permeable to water vapor. Such a membrane could be laminated to a shell fabric to make lightweight breathable protective clothing. New materials are sought for liner membranes which result in performance improvements that either increase the low-concentration CWA threat protection of current light weight garments, without limiting the physical activity level of the soldier, or which offer a high-concentration CWA threat protection, while decreasing the heat stress associated with non-breathable protection. Recent basic research advances in academia in composites of elastomers and nanopore-forming additives show that membranes can be made to provide an adequate level of water permeation and simultaneous CWA protection. A high level of protection against TICs and TIMs should also possible using this class of materials. The highly selective nature of these membranes is a result of the nanopores in the barrier membrane. Similar composites need to be further developed and fully evaluated for use as a membrane in individual chemical protective suits.

PHASE I: Develop and demonstrate a new breathable elastomer membrane liner material for chemical agent protective clothing. Characterize the permeation of CWA simulants, TICs, TIMs and measure the water vapor transmission rate. Compare the results against samples of butyl rubber gloves and JLIST suits. Based on the permeation results, determine the feasibility of using the membrane in protective garments.

PHASE II: Scale up production of the membrane liner material and develop methods for laminating the liner to garment fabrics. Measure the permeation resistance to live chemical agents in addition to common TICs and TIMs. Test for durability, flame resistance, stability under environmental conduction and repeated laundering.

PHASE III: Commercialize the liner membrane and transition it into the appropriate acquisition program. DoD will purchase a minimum of 4 million additional CB protective garments from FY 07 through FY 12. Additionally, private sector applications will be sales to the domestic preparedness market including Dept. of Homeland Security, local police, EMS, etc. Also, there are applications in the chemical industry for protection from hazardous chemicals.

REFERENCES:
1. Strategies to Protect the Health of Deployed U.S. Forces: Force Protection and Decontamination; Wartell, M. A.; Kleinman, M. T.; Huey, B. H.; Duffy, L. M., Eds.; National Academy Press: Washington, DC; 1999.

2. Jizhu Jin, et al.; "Cross-linked Lyotropic Liquid Crystal-Butyl Rubber Composites: Promising "Breathable" Barrier Materials for Chemical Agent Protection Applications" Chemistry of Materials, 2005, 17, 2, pg 224-226.

3. Xiaoyun Lu, et al.; "Cross-linked Bicontinuous Cubic Lyotropic Liquid Crystal-Butyl Rubber Composites: Highly Selective, Breathable, Barrier Materials for Chemical Agent Protection" Advanced Materials, 2006, Vol 18, no 24, pg 3294-3298.

KEYWORDS: elastomer, breathable membrane, protection, chemical warfare agents, TICs, TIMs

A08-T016 TITLE: <u>Devices and Textiles for Broad-Spectrum Protection</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

OBJECTIVE: Develop new reactive, porous solids to supplement or replace existing materials used for individual troop protection against chemical and biological warfare agents (CBWs) and toxic industrial chemicals (TICs).

DESCRIPTION: Activated carbon is widely used in filtration applications to remove chemical contaminants from gases. The major benefits of activated carbon are its large surface area and extensive porosity, which allow it to adsorb large amounts of chemicals, and its low cost of production. However, the majority of its porosity consists of micropores, which can hinder the diffusion of molecules to adsorptive sites, and its color (black) makes it difficult to colorimetrically determine when all of the adsorptive sites have been exhausted (end-of-life). Activated carbon does not remove biological contaminants; thus, broad-spectrum protection against chemical and biological contaminants has usually been accomplished by combining it with HEPA filters. However, the biological contaminants are simply excluded by this method, not destroyed. Recent antimicrobial work and new nanoporous designed materials in academia have led to advances in this area.

Consequently, new porous solids with the following characteristics are needed: (1) contain a highly interconnected micro/meso/macroporous framework with a large fraction of meso/macropores, as determined from powder X-ray diffraction, N2 physisorption, and solid state NMR techniques; (2) retain a total surface area in excess of 500 m2/g; (3) present a white or light background to facilitate colorimetric end-of-life detection; (4) be synthesized in a rapid, facile, and low cost method; (5) be easily doped with metals such as Cu, Ag, Zn, Mo, and V for enhanced adsorption. These solids must be combined with reactive polymers that could be coated onto HEPA filters or textiles, to produce devices and materials that meet the following criteria: (1) show decreased breakthrough times of three types of chemical agents and ten types of TICs over current technologies based on activated carbon; (2) when impregnated with organic dyes, show rapid (less than 2 min) color changes to indicate adsorption against CBWs and

TICs; (3) show at least a 4 log kill of viruses and 5 log kill of other biological contaminants. The devices and materials should be consistent with currently fielded technology, so that they could be used with current equipment. The proposer should have a track record of research and collaboration in the areas of porous solids and filtration.

PHASE I: Synthesize two types of porous solids with integrated networks of pore with various diameters and dope them with metals. Prepare pellets with various mesh sizes and perform breakthough tests with five types of TICs and three types of chemical warfare agent simulants and identify decomposition products, if any. Identify organic dyes that could be incorporated into the pellets and measure the rate of color change upon exposure to simulants.

PHASE II: Downselect for the optimum combination of porous solid, mesh size, and metal dopants based on Phase I results. Perform pilot plant level scale-up of synthesis of porous solids and pellets. Combine pellets with HEPA filters coated with reactive polymers and demonstrate at least 4 log kill against one viral biological warfare agent surrogate and 5 log kill against three other BWA surrogates. Develop devices that mimic existing gas mask cartridges and textiles used in broad-spectrum protection applications. Perform tests against live-agent CBWs and TICs, and several cross-interference and field interference tests, identifying any decomposition products.

PHASE III DUAL USE APPLICATIONS: This phase should include large-scale synthesis and production of the appropriate porous solids and pellets as well as preparation and sale of the resulting products. The devices and textiles that result from this project have the potential for use in industrial and civil defense fields where filtration of and protection from chemical and biological contaminants is required, for example in the health care field. There is also potential use by first responders and emergency responders.

REFERENCES:
1. Clark, R. M.; Lykins, Jr., B. W. Granular activated carbon: Design, operation, and cost; Lewis Publishers, Inc.: Chelsea, MI, 1989.

2. Chemical and Biological Terrorism: Research and Development to Improve Civilian Medical Response; National Academy Press, Washington, DC, 1999.

3. Soler-Illia, G. J. de A. A.; Sanchez, C.; Lebeau, B.; Patarin, J. "Chemical Strategies To Design Textured Materials: from Microporous and Mesoporous Oxides to Nanonetworks and Hierarchical Structures," Chem. Rev. 2002, 102, 4093.

4. Ringenbach, C. R.; Livingston, S. R.; Landry, C. C. “Vanadium-Doped Acid-Prepared Mesoporous Silica: Synthesis, Characterization, and Catalytic Studies on the Oxidation of a Mustard Gas Analogue,” Chem. Mater. 2005, 17, 5580 -5586.

KEYWORDS: filtration, porous solids

A08-T017 TITLE: Ultra-Low-Noise Infrared Detector Amplifier for Next Generation Standoff Detector

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: To design, build, and demonstrate a new class of lower-noise Optical Detector Amplifiers for Chemical and Biological Detection and other Electro-Optical sensors.

DESCRIPTION: Currently, both Active (Laser) and Passive Infrared Standoff Detectors require very sensitive optical detectors, with very-low-noise amplifiers. Current low-noise amplifiers contain self-generated and externally induced noise as well as detector and scene background noise. This noise affects the training of current state-of-the-art detection algorithms, causing a loss of discrimination and therefore a need to establish higher detection thresholds to meet military requirements. Recently, amplifiers employing active noise cancellation, using feed-forward and other circuit techniques to reduce noise have become available for use with audio earphones, GPS receivers, and other applications. However, these circuits have generally been implemented in Si or SiGe ICs and produce noise figures in the 2-3 dB range. Low noise amplifiers using compound semiconductor GaAs-based or InP-based PHEMTs produce reduced noise amplifiers, and noise figures less than 1 dB up to X-band are obtained. Also, extremely low-power, low-noise amplifiers have been fabricated using ABCS (antimony-based compound semiconductors) and noise figure on the order of 1 dB at X-band have been obtained. However, to date active noise cancellation circuit techniques have not been used with the compound semiconductor amplifier ICs. Also, nano-material shielding and packaging techniques can be employed to reduce noise. In order to obtain increased detection performance, this STTR will investigate the design of a new ultra-low-noise amplifier; build and fully evaluate its performance; quantify its improvement on threshold detection. For example, in a passive standoff sensor, such as the chemical imaging sensor, a HgCdTe detector is interrogated million of times per second. At each interrogation a very small voltage is amplified and presented to an analog to digital converter for readout. An ideal amplifier would be able to operate at speeds in excess of 500 MHz while producing voltages that are accurate to at least sixteen bits of resolution at the A to D board. The amplifier will be required to operate in field environments and should be immune to intense physical vibration and EM fields.

PHASE I: In Phase I, a tradeoff study between ultra-low-noise amplifier designs will be conducted. The use of compound semiconductor HEMTs for the active device, integrated with feed-forward and/or other noise cancellation circuits, with the goal of producing an ultra low noise amplifier with noise figure under 1 dB with bandwidth up to 1 GHz is desired. The design will focus on high-speed Fourier transform spectrometers operating in the long-wave infrared region, where the readout from a HgCdTe detector or detector array will provide the small signal to be amplified. The most promising low noise transistor and active noise cancellation technique, nano-material shielding and ultra-low-noise circuitry will be examined and identified.

PHASE II: A breadboard device will be built. The breadboard will be tested and design improvements made. The breadboard's performance will be fully evaluated, including possible substitution into a working military sensor. Actual delivered-system performance improvements will be the basis of final evaluation. All potential additional improvements will be documented, and the best will be included in a final prototype.

PHASE III: It is not anticipated that the improved amplifier will be markedly more expensive, larger, or more complicated to incorporate than current amplifiers. As an electronic subassembly, with fully evaluated improved performance for ultra-low-level and wide-dynamic range, it will have immediate application in Chemical and Biological Detectors, both passive and Laser based; Forward-looking Infrared (FLIR) systems, both military and commercial; and extended application in Hyperspectral Imaging.

REFERENCES:
1. W. Wadsworth, “8x8 element mosaic imaging FT-IR for passive standoff detection”, Imaging Spectrometry XI. Edited by Shen, Sylvia S.; Lewis, Paul E.. Proceedings of the SPIE, Volume 6302, pp. 630202 (2006).

2. W. Wadsworth, D.J. Williams, “Mobile remote sensing FT-IR for plume detection”, Imaging Spectrometry XI. Edited by Shen, Sylvia S.; Lewis, Paul E.. Proceedings of the SPIE, Volume 6302, pp. 630201 (2006).

3. W. Wadsworth, J. Dybwad, and D. Stone “Mosaic imaging Fourier transform spectrometer applications”, Proceedings of SPIE -- Volume 5806, Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XI, Sylvia S. Shen, Paul E. Lewis, Editors, 255-266 (2005).

4. W. Wadsworth, J. Dybwad, “Rugged high-speed rotary imaging Fourier transform spectrometer for industrial use”, Proc. SPIE Vol. 4577, p. 83-88, Vibrational Spectroscopy-based Sensor Systems, Steven D. Christesen; Arthur J. Sedlacek; Eds. (2002).

5. J.O. Jensen, A.I. Ifarraguerri, W.R. Loerop, W. Wadsworth, J. Dybwad, “Chemical imaging system”, Proc. SPIE Vol. 4574, p. 52-62, Instrumentation for Air Pollution and Global Atmospheric Monitoring, James O. Jensen; Robert L. Spellicy; Eds. (2002).

6. A.I. Ifarraguerri, J.O. Jensen, “Chemical imaging system: current status and challenges”, Proc. SPIE Vol. 4381, p. 143-149, Algorithms for Multispectral, Hyperspectral, and Ultraspectral Imagery VII, Sylvia S. Shen; Michael R. Descour; Eds. (2001).

7. D. Maliniak, “An FPGA-Based Spectrometer For Solar Observation”, Electronics Design, September 28, 2006.

8. S. Stanko , B. Klein, and J. Kerp, "A field programmable gate array spectrometer for radio astronomy", Astronomy & Astrophysics 436, 391–395 (2005).

9. I. Frohlich, et al, "Pattern recognition in the HADES spectrometer: an application of FPGA technology in nuclear and particle physics", Proc. Of IEEE International Conference on Field-Programmable Technology, 2002.

10. J.B. Hacker, J. Bergman, G. Nagy, G. Sullivan, C. Kadow, H.K. Lin, A.C. Gossard, M. Rodwell, and B. Brar, "An Ultra-Low Power InAs/AlSb HEMT X-Band Low-Noise Amplifier and RF Switch," CS MANTECH Conference, April 24-27, Vancouver, British Columbia, Canada.

KEYWORDS: Ultra-Low Noise, Infrared Detector, Amplifier, Chemical Detection, Biological Detection, FLIR, Hyperspectral, Sensing, Standoff

A08-T018 TITLE: Vision-based 3D Simultaneous Localization and Mapping

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: The objective of this project is to design and demonstrate a compact, lightweight, wearable device for vision-based 3D Simultaneous Localization and Mapping (SLAM) for indoor exploration and mapping.

DESCRIPTION: The complexity of urban environments poses unique challenges and risks for the U.S. forces to conduct urban operations. The capability of 3D SLAM provides vital information for situation awareness with detailed location and map information. The majority of existing efforts on 3D SLAM has been focused on solutions combining lidar/ladar scan with visual imagery and Global Positioning System (GPS) signals [1, 6]. Recent research has theoretically shown the possibility of vision-based 3D SLAM solutions based on bearing only measurements. The location and map information is obtained by employing estimation techniques such as Extended Kalman Filter, particle filtering or expectation maximization [2-5]. Vision-based solution is passive, portable, compact, low cost, and power-saving that potentially has a broad range of military applications including navigation of robotic systems and soldier position localization with wearable or helmet-mounted devices. Passive solutions provide an extra layer of protection.

The U.S. Army seeks development of a compact, lightweight, wearable device for vision-based 3D positioning and mapping capability for indoor exploration. The intended applications include robotic navigation and solider position localization when soldiers enter into buildings and/or climb stairs. The device should be passive without emissions such as radio frequency signals or active light. Availability of GPS signals should not be assumed but can be utilized whenever available, for example when the devise is placed outdoor. Types of available imagery sensors include passive Charge-Coupled Device (CCD) cameras and/or night vision systems. The device may include additional passive sensors such as Inertial Measurement Unit (IMU), magnetometer, or compass. However, utilization of IMU must be limited to small size and low cost solutions in which compensation of drift error is needed. Either stereo or monocular camera may be used. Real time position location and mapping capability is expected. The system should use Commercial Off-The-Shelf (COTS) hardware. Ideally, the device is of the size of an ordinary cell phone, but a solution with a clear path toward this goal is acceptable. Collaborative 3D SLAM by multiple devices is not required but should be an option for future developments.

PHASE I: Effort in Phase I may be directed to feasibility study by designing algorithm(s) that provide reliable location information. Sensor modalities used in the design should be identified and must be passive without emissions. The solution should be a function of resolution available. The algorithm(s) should be validated for indoor operations through methods such as computer simulation either at the system level or component-wise. Quantitative characterization of algorithm performance should be obtained. Strengths and deficiencies of the proposed algorithms should be explicitly identified and documented. Algorithms should be ready for implementation for Phase II.

PHASE II: Efforts should be focused on prototyping. A functioning system should be developed. Algorithms should be further refined for improved performance and reliability. Performance evaluation should be thoroughly conducted for intended applications under real indoor environments and properly documented.

PHASE III DUAL-USE APPLICATIONS: Phase III will further develop and refine the device including size reduction and performance improvements for commercialization. The technology will be ready for transition to the Army through PEO offices and defense industry such as General Dynamics. The capability of passive 3D SLAM will provide critical situation awareness to support urban operations with additional layer of force protection. This capability can be used by police and first responders for building search and rescue.

REFERENCES:
1. DeSouza, G.N., and A.C. Kak, "Vision for Mobile Robot Navigation: A Survey," IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 24, No. 2, pp.237-267, February 2002.

2. Jensfelt, P., D. Kragic, J. Folkesson, and M. Bjorkman, "A Framework for Vision Based Bearing Only 3D SLAM," Proc. 2006 IEEE Intl. Conf. on Robotics and Automation (ICRA 2006), pp.1944-1950, May 15-19, 2006.

3. Langelaan, J., and S. Rock, "Passive GPS-Free Navigation for Small UAVs," IEEE Aerospace Conf., March 5-12, 2005.

4. Lemaire, T., S. Lacroix, and J. Sola, "A Practical 3D Bearing-Only SLAM Algorithm," Proc. 2005 IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS 2005), pp.2449-2454, August 2-6, 2005.

5. Se, S., D. Lowe, and J. Little, "Vision-based Global Localization and Mapping for Mobile Robots," IEEE Trans. on Robotics, Vol. 21, No. 3, pp.364-375, June 2005.

6. Thrun, S., "Robotic Mapping: A Survey," In G. Lakemeyer and B. Nebel, editors, Exploring Artificial Intelligence in the New Millenium. Morgan Kaufmann, 2002.

KEYWORDS: Simultaneous localization and mapping, SLAM, navigation, 3D mapping, passive, localization, autonomous systems, robotics

A08-T019 TITLE: Development of a Soldier Battlespace Auditory Analyzer System

TECHNOLOGY AREAS: Sensors, Human Systems

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

OBJECTIVE: To develop a low weight Soldier acoustic sensor system that takes outside audio, extracts relevant acoustic information, and provides graphics and/or audio for use on a Soldier’s display to provide alerts (personnel, vehicles, weapons fires, etc). These alerts include identity, approximate range and azimuth for each source, along with a confidence value.

DESCRIPTION: The auditory environment experienced during military operations in urban terrain (MOUT) can be chaotic as well as simply loud. Important noises, such as weapon manipulations, rock slides, floor creaks, etc. may be masked by not only the Soldier’s own movements and equipment, hearing protection, and vehicles, etc. but by those of the normal environment as well. As requested in the PEO Soldier FY07 Critical Technology Shortfalls Matrix: SWAR.06.10, a methodology is needed that can do a form of automated auditory search, filtering, amplification and source classification, providing a processed output that not only can alert an individual or unit, but can also determine the likely identity for a particular sound that may be embedded in sufficient background noise that it would be undetectable to an unaided human. This algorithm would use as input existing auditory sensors (microphones, ground vibration sensors, etc.) and process these in such a manner that even though the entire auditory field would be analyzed, false identifications would be rejected to such a degree that there would be negligible cost in false alarms involved in its use. Recent successes in using multi-stage state vector machines coupled with biologically inspired neuron-like computational strategies for image analysis and target detection/identification have shown human levels of detection with very low false positive rates in analyzing natural scenes for vehicle detection. This methodology can learn from a small series of exemplars to efficiently process a large amount of data, and is not restricted to only visual images. These results raise the possibility that innovative research using these types of approaches in the auditory domain might prove quickly successful, given that the inputs will be serial rather than parallel, and thus probably simpler to decode than the visual environment.

PHASE I: (Feasibility Study) Develop a hardware/software system for audio source recognition, consisting of specially designed low weight helmet or Soldier-mounted devices such as mechanical filters (for improved source localization) and multiple microphones, audio signal preprocessing, and software/hardware-based feature extraction and target recognition set of computational procedures. The entire system will be tested and optimized on an initial set of field audio recordings containing sounds associated with body movements, gun loading, and running machinery. This system will be demonstrated on a low to average commercial laptop computer system.

PHASE II: (Prototype Delivery) Year 1: Most of the computational procedures will be algorithmically optimized and implemented in hardware as an integrated circuit suitable to be housed either within the helmet or connected to an appropriately selected equipment host on the Soldier.
Year 2: Build prototype system suitable for adoption into the available remaining processing power of the Land Warrior / Future Force Warrior / Ground Soldier System computer system. More realistic field data will be collected with the initial hardware implementation and used for further advanced testing, optimization, evaluation, and product design.

PHASE III : The finalized system will be optimized for manufacturing in quantity and in conjunction with PEO Soldier – Project Manager Soldier Warrior, integrated into the sensor and computing suite for Land Warrior / Future Force Warrior / Ground Soldier System.

REFERENCES:
1. Land Warrior System fact Sheets at http://www.peosoldier.army.mil/factsheets/SWAR_LW.pdf

2. Favorov, O.V. and Ryder D. (2004) SINBAD: a neocortical mechanism for discovering environmental variables and regularities hidden in sensory input. Biological Cybernetics 90: 191-202.

3. Favorov, O. V., Ryder, D., Hester, J. T., Kelly, D. G. and Tommerdahl, M. (2003) The cortical pyramidal cell as a set of interacting error backpropagating networks: a mechanisms for discovering nature's order. In: Theories of the Cerebral Cortex, R. Hecht-Nielsen and T. McKenna (eds.), Springer, London, pp.25-64.

KEYWORDS: Sounds, acoustic processing, sensors, identification, localization, automation, Land Warrior, Future Force Warrior, Ground Soldier System, audio amplification

A08-T020 TITLE: Dilution refrigerator technology for scalable quantum computing

TECHNOLOGY AREAS: Materials/Processes, Sensors

OBJECTIVE: Design and development of innovative dilution refrigerator technology and cryostats that would enable scalable quantum computing and minimize helium usage.

DESCRIPTION: Many physical systems for qubits require millikelvin temperatures for their operation. Examples are superconductor qubits and several semiconductor qubits. Dilution refrigerators provide the essential technology to achieve and sustain these operational temperatures. Current cryostats involving dilution refrigerators are suitable for "one-of" and small-scale low temperature exploratory physics experiments. While this capability has been sufficient for initial experiments on qubits, such cryostats are insufficient in size and performance for experiments involving large numbers of qubits and for the rapid turnaround needed for scalable quantum computing development. Direct scale-up of current dilution refrigerator technology and cryostat systems is neither simple nor is success guaranteed. Therefore, research and development on dilution refrigerator technology through better understanding of the physics of the cooling processes involved is needed. Further, shortages and escalating costs, and the volumes of helium required, are becoming hurdles. This motivates research and development of approaches that eliminate or dramatically reduce the use of helium. Pursuit of alternate technology to current helium refrigerators is encouraged.

PHASE I: Research and development areas include: (1) Improvements in cooling performance through better understanding and control of the 3He and 4He phase separation dynamics. (2) Pursuit of alternate approaches not based on helium, such as adiabatic demagnetization. (3) Strategies for rapid turn-around of experiments, such as pre-cooling and staged cooling possibly using pulsed-tube refrigeration. (4) Techniques for the minimization of helium usage without the installation of elaborate recovery equipment, such as closed-cycle technology. Proposed solutions must consider needs and constraints of anticipated experiments, such as the ease of use, laboratory space, sufficient space and access in the cryostat for signal and control electronics and wiring, robustness, and turn-around time. Collaboration with experimental groups pursuing qubit experiments for cognizance is highly encouraged. During Phase I the following must be completed: conception and design of the cryostat system, estimates of performance, and assessments of feasibility. Initial prototypes must be capable of handling tens of qubits but the proposed technology must be scalable to larger numbers of qubits. The developed system should have the capability to cool a large qubit sample to dilution refrigerator temperatures below 25 mK.

PHASE II: Finalize design and build prototypes of the cryostat. Provide a demonstration deployment that validates the technology at a laboratory that does suitable qubit experiments. The Phase-II program shall provide a plan to transition the technology to commercial development and deployment.

PHASE III DUAL USE APPLICATIONS: The technology developed here has impact on the successful scale-up and deployment of quantum computers. In addition to critical national security applications, quantum computing is anticipated to have an impact on commercial applications involving hard computational problems such as optimization, routing, planning and scheduling. The technology developed here is also anticipated to have broader impact on low temperature physics experiments by enabling new and larger scale experiments not possible with current technology.

REFERENCES:
1. "Experimental Techniques in Condensed Matter at Low Temperatures",
Robert C. Richardson and Eric N. Smith, Addison-Wesley, 1988

2. "Implementing Qubits with Superconducting Integrated Circuits",
Michel H. Devoret and John M. Martinis, Quantum Information Processing vol. 3 (2004)

KEYWORDS: Dilution refrigerators, cryostats, superconducting qubits, solid-state qubits, quantum computing, low-temperature physics.

A08-T021 TITLE: Eye-safe Optically-Pumped Gas-filled Fiber Lasers

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To develop an eye-safe, optically-pumped molecular laser based on gas-filled fibers, with high efficiency and coherence for enhanced Army capabilities of countermeasures, communications, and sensing.

DESCRIPTION: Optically-pumped gas lasers (OPGLs) offer the promise of high-power continuous wave (cw) narrow-band emission at various wavelengths from the visible to the infrared. The gain medium in an OPGL is a gas that is pumped by an optical source. Due to dramatic improvements in semiconductor diode lasers or fiber laser technologies, inexpensive high-power continuous wave pumps at a variety of wavelengths are now available. These optical sources have increased the interest in OPGLs for various applications including infrared (IR) countermeasures, free space optical communications, remote chemical threat detection, and high-power laser defense. In addition, the development of hollow optical fibers has made possible a new class of lasers based on gas-filled fibers. Such fibers provide for longer interaction lengths with the optical pump and allow for improved energy transfer efficiency from the pump laser to the gas medium. Furthermore, when multiple incoherent optical sources are applied to a gas laser medium, the gases can convert the input power into a single coherent output laser beam. The high coherence of such gas lasers would be ideal for power scaling through source combination.

Semiconductor diode lasers have been used to optically pump gases enclosed in glass capillary cells and high conversion efficiency has been demonstrated in molecular gases including HBr [1] and CO [2]. However, the relatively small gain available in a dilute gas requires long interaction lengths, limiting their scalability and portability. The drawbacks to OPGLs demonstrated in glass cells can be overcome by creating OPGLs in hollow optical fibers. New hollow optical fiber technologies such as photonic bandgap fiber and kagome fiber [3] dramatically reduce the optical loss over that of capillary tubing, and offer an ideal solution to the need for long interaction lengths.

This project aims to demonstrate an optically-pumped laser based on molecular gas-filled fibers (OPGFL). The emission of the OPGFL is to be at a wavelength in the eye-safe spectral region. In order to achieve this goal, the energy levels of the selected molecular gas must be identified and studied to determine the desired pump and lasing wavelengths. Commercially available semiconductor diode or fiber pump lasers must be identified for use as the optical pumps. Appropriate quenching mechanisms of the molecular gas must be specified to maintain population inversion. Design of the hollow optical fiber must be analyzed to optimize the interaction between the pump and lasing wavelengths and the appropriate fiber cavity geometry must be determined. Methods for splicing solid-core to hollow-core fiber [4] losses must be improved to mitigate coupling losses. Phase locking of multiple sources to produce higher output powers must be investigated to control the phase and frequency of the laser.

PHASE I: Proof-of-concept of an eye-safe, optically-pumped laser system based on molecular gas-filled fibers should be achieved. The appropriate molecular lasing medium, the appropriate optical pump lasers, the quenching gas, and hollow fiber geometry should be identified. Commercially available pump lasers and optical fibers are to be used. Optical gain is to be demonstrated.

PHASE II: An eye-safe, molecular gas-filled fiber laser system should be demonstrated based on results from Phase I. Various molecular gases will be studied to determine most efficient optical transitions. Design of optimum hollow optical fiber geometries will be completed and specialty fibers will be procured. Laser power, emission and spectral characteristics will be measured. Phase locking of multiple sources to produce higher output powers will be investigated.

PHASE III: Dual Use Applications:
This effort will produce compact, eye-safe lasers, capable of high output powers with good beam quality and narrow-line cw emission. Investigations into coherently combining multiple OPGFLs will demonstrate the power-scalability for military applications including IR countermeasures, free space optical communications, remote chemical threat detection, and high-power laser defense. The same technology will find civilian applications in navigation, metrology, telecommunications and frequency standards.

REFERENCES:
1. C. S. Kletecka, N. Campbell, C. R. Jones, J. W. Nicholson, and W. Rudolph, "Cascade lasing of molecular HBr in the four micron region pumped by a Nd: YAG laser," Ieee Journal Of Quantum Electronics 40, 1471-1477 (2004).

2. J. E. McCord, A. A. Ionin, S. P. Phipps, P. G. Crowell, A. I. Lampson, J. K. McIver, A. J. W. Brown, and G. D. Hager, "Frequency-Tunable Optically Pumped Carbon Monoxide laser," IEEE Journal Of Quantum Electronics 36, 1041-1052 (2000).

3. F. Couny, F. Benabid, and P. S. Light, "Large-pitch kagome-structured hollow-core photonic crystal fiber," Optics Letters 31, 3574-3576 (2006).

4. R. Thapa, K. Knabe, K. L. Corwin, and B. R. Washburn, "Arc fusion splicing of hollow-core photonic bandgap fibers for gas-filled fiber cells," Optics Express 14, 9576-9583 (2006).

KEYWORDS: molecular laser, gas-filled fibers, eye-safe

A08-T022 TITLE: Ionic Liquid Monopropellant Based Gas Generator

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Design, develop and demonstrate the feasibility of a on-demand gas generator based on ionic liquid monopropellant that supplies pressures up to 3500psi and is suitable for use with pressurizing liquid and gelled fuel and oxidizer tanks.

DESCRIPTION: Recently, several families of energetic ionic liquids have been synthesized and characterized with potential as low-toxicity and reduced hazard candidate replacement materials for conventional (hydrazine based) monopropellants (1,2). Ionic liquids demonstrate unique attributes of surface tension, vapor pressure, thermal stability and reactivity. They have been demonstrated for use as monopropellants over catalyst beds. Gel based rocket motors are currently being considered as a path to decreased sensitivity to damage and insult. Gelled fuel and oxidizer delivery is achieved through tank pressurization via high pressure gas generators. Currently solid propellant gas generators are used leading to large variation in tank pressurization affecting motor performance. On demand gas generators are sought to better maintains consistent tank pressure in the fuel and oxidizer storage tanks. The rocket motors under consideration are pintle injector type; therefore the gas generator must be able to rapidly respond to changing motor fuel/oxidizer demands. Issues to be addressed include rapid ignition, exhaust temperature and inertness, inadvertent ignition sensitivity, and combustion stability at high pressure. Energetic ionic liquids used as monopropellants may have the potential to be used as a low toxicity, on-demand gas generators. This will increase the stability and operating range of projected gelled fuel/oxidizer rocket motors.

PHASE I: Identify and evaluate available ionic liquid monopropellants and ignition systems; recommend best candidate materials. Shock, electrostatic discharge and thermal sensitivity issues as well as toxicity shall be considered in recommendation of final system. Demonstrate experimentally: rapid, controlled ignition of the selected monopropellant and ignition system.

PHASE II: Design, construct and evaluate an on-demand ionic liquid monopropellant based gas-generator to pressurize fuel and/or oxidizer tanks at various pressures up to 3500psi and gas molar flow rate of at least 2.7moles/s (at 1500degF), and maximum exhaust gas temperature of 1500degF, across a 500psi pressure drop into a backpressure of 2000psi, with system response time of less than 10ms. The system must be capable of controlling and maintaining steady pressure, selectable between 2700-3500psi, in a tank undergoing rapid flow fluctuations. Deliver one complete system to the Army for evaluation testing.

PHASE III Dual Use: Development of on-demand gas generator using low-toxicity, low hazard materials will have impact on a wide range of military and commercial systems such as APU start-up, air-bag inflation, turbo-pump power and satellite positioning.

REFERENCES:
1. Farhart, K. Amariei, D., Batonneau, Y. Kappenstein and Ford, M. (2007) AIAA 2007-5642

2. Drake, G., Kaplan, G., Hall, L., Hawkins, T., Larue, J., (2006) Journal of Chemical Crystallography, v37, 15ff

3. Amariei, D., Courthéoux, L., Rossignol, S., and Kappenstein, C., (2007) Chemical Engineering and Processing v46 pp165-174

KEYWORDS: ionic liquid, gas generator, mono-propellant

A08-T023 TITLE: In-Situ Reforming of Middle-Distillate Fuels Through Catalytic Cracking of Long-Chain Hydrocarbon Molecules

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: This STTR topic envisions fundamental study of small-scale, real-time, partial refining of military diesel and JP-8 fuels to produce reformates having a maximum hydrocarbon molecule chain length of C12Hx.

Reducing the maximum hydrocarbon order from C20Hx to C12Hx, and thereby its molecular weight, would change the nature of the fuel with respect to its flash point, heat of vaporization, specific gravity, etc. This fuel property shift could lead to important benefits and new applications for military fuels.

An important potential application would be the use of such in-situ refining techniques to convert diesel or JP-8 to higher volatility reformate streams for the purpose of enabling spark ignition in low-compression "gasoline" engines.

Background: One of the Army's technology gaps in the area of power & energy is entitled "Limited Power Spectrum". This technology gap refers to the limited options available in the power spectrum or range of 250-2000 W. This is deemed the "transitional" power range because it spans the divide between the use of batteries on the low end and logistically-fueled power sources on the high end. Batteries accommodate most power needs below 250W and the 2 kW Military Tactical Generator (MEP-501/531A) addresses power needs 2 kW and above. Absent is a logistically-fueled alternative in the transitional range (250-2000 W). The following technology challenges contribute to this situation:

- Transitional power source alternatives are limited by scaling and log fuel compatibility
- Otherwise suitable technologies such as Brayton-cycle systems and thermoelectrics exhibit very low efficiencies (< 6% fuel-to-electric)
- JP-8 use is difficult in small burners due to poor fuel-air control and turn-down control
- Existing transitional power sources and APUs are exceptionally noisy and result in detectability and interoperability problems.
- Available engines in the 250-2000W range are exclusively of the commercial gasoline type.

The proposed 2009 Army Technology Objective (ATO) entitled "R.CER.2009.03/Mobile Power" will address these challenges through materials and component research. This proposed ATO, however, is not designed to investigate the chemistry of logistic fuels and the means by which fuel processing may contribute to advances in this transitional power regime. This STTR will enable fundamental study in the area of in-situ processing of logistics fuels to identify advanced methods to achieve more volatile fuels from standard military logistics fuels.

DESCRIPTION: The DoD is currently addressing fuel reformation of military logistic fuels, but for purposes other than which is sought herein. Current efforts to reform fuels focus mainly on fuel cell applications (solid oxide, PEM, etc.) For these efforts, reforming is exceedingly difficult since a hydrogen-rich reformate free from sulfur is sought. The research proposed under this STTR is intended to benefit traditional reciprocating engines, not fuel cell applications. For this reason alone, sulfur removal is not necessary. The reforming proposed herein will retain a large portion of the long-chain hydrocarbon molecules intact, but will remove the higher order (C13Hx and larger) molecules through cracking or other processes. Essentially, on-board reforming of diesel and JP-8 fuels to produce a "gasoline-like" fuel is proposed. Replicating the molecular content of gasoline is not important, but attaining fuel property shifts in the areas of volatility, flash point, resistance to compression ignition, and other areas that would render the fuel acceptable for use in a low compression, spark-ignition engine is of great interest.

PHASE I: Investigate the various means for partially reforming military fuels in a real-time, in-situ process to produce a more volatile fuel. As a minimum, techniques involving plasmas, steam reforming, catalytic partial oxidation, and autothermal reforming shall be investigated, and the characterization of relative performance shall be based on available literature and laboratory measurements. Preliminary experimental results supporting the selected fuel processing technique are desirable but not required. Critical technology barriers and scalability limits shall be addressed for each of the techniques. Projected performance metrics shall be provided, and physical attributes (size, weight) shall be estimated for each technique as well. The most promising candidate techniques shall be identified for a more comprehensive investigation in Phase II.

PHASE II: This phase will involve a full-scale lab evaluation of the process for diesel and JP-8 fuels, whereby a full reforming subsystem is employed, and instrumentation is employed for determining the molecular content of the fuel and reformate. In addition, measurements of the property shifts shall be conducted. Sensitivity analyses shall be conducted to determine the impact of changes in the reforming method on reformate composition and properties. A single or multiple reformats shall be selected and utilized to operate a production gasoline engine in the 250-2000 W range. Baseline characterization of performance shall be assessed.

PHASE III: Military application: Such applications include the ability to use logistics fuels in new applications such as small commercial gasoline engines. These applications will enable the military to meet the transitional power needs in the 250-2000 W power range using logistics fuels. Commercial application: This research may enable multi-fuel engines for the commercial market, and a method of altering fuel properties in real-time to respond to changing loading conditions, varying environmental conditions, etc.

REFERENCES:

1. Speight, James G, The Chemistry and Technology of Petroleum, 1991.

2. Adler, U, editor, Automotive Handbook, 1986.

3. Heywood, John B, Internal Combustion Engineering Fundamentals, 1988.

4. Avallone, Eugene A. and Baumeister, Theodore III, Marks' Standard Handbook for Mechanical Engineers, 1996.

KEYWORDS: reformation, fuel reforming, fuel processing, fuel conversion

A08-T024 TITLE: Advanced Point Sensor

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: We are seeking novel approaches to demonstrate feasibility of a point, combined chem and bio sensor.

DESCRIPTION: Point bio sensors that operate in real time mode, are typically based on the LIF (laser induced fluorescence) phenomenology, but this means of detection has the problem that discrimination among bio agent types is relatively unspecific. The consequence is high false alarm rate. The method of differential scatter (DISC) in the LWIR (long wave infrared) as demonstrated in the field with the FAL (Frequency Agile Laser) has shown good sensitivity and specificity. FAL was initially demonstrated to offer sensitive detection of chemicals by differential absorption lidar (DIAL), which now makes possible the detection of both chemical and biological agents with a single transmitter/receiver set. Applying this fundamental technique to very sensitive detection methods such as Cavity ringdown spectroscopy (CRS) makes possible the development of very sensitive, species specific, compact, combined chemical and biological agent sensors. Specific interrogation method of agent particles being captured and its advantages are to be identified. Methodology is to address sensitivity levels for chemical and biological agents resulting from the approach chosen. Spectral resolution required to provide chemical identification and bio discrimination as well as spectral signature is to be shown.

Advanced algorithms have been developed for chemical and biological detection in the LWIR and these algorithms can be applied to the new case of point sensors based on the same phenomenologies. It is of interest to further develop these algorithms.

PHASE I: Perform analysis and systems study to show feasibility of a DISC/DIAL point sensor approach and develop a demonstration sensor conceptual design.

PHASE II: Develop the sensor detailed design. Fabricate a testbed point sensor and demonstrate its detection and discrimination capabilities. Investigate combined biological and chemical detection. Perform an assessment of available algorithms and develop a roadmap for further work including correlation with field test data.

PHASE III DUAL-USE APPLICATIONS: In Phase III, a prototype point sensor system would be built for field trials. This would lead in the future to a combined chemical and biological sensor suitable for deployment. Development of such a sensor would be of great benefit in homeland defense applications and for environmental pollution monitoring.

REFERENCES:

1. R. Vanderbeek, “Aerosol Backscatter Field Measurements Of Chem-Bio Simulants Using A Windowless Vortex Chamber”, Proceedings Sixth Joint Conference On Standoff Detection For Chemical and Biological Defense, Williamsburg, VA October 25-29, 2004

2. R. E. Warren, “Discriminating Aerosols By Multi-Wavelength Lidar”, Proceedings Sixth Joint Conference On Standoff Detection For Chemical and Biological Defense, Williamsburg, VA October 25-29, 2004

3. D. B. Cohn, “Compact CO2 TEA Lasers and Chemical Sensors”, Proceedings Sixth Joint Conference On Standoff Detection For Chemical and Biological Defense, Williamsburg, VA October 25-29, 2004

4. D. Cohn, J. Fox and C. Swim, "Frequency agile CO2 laser for chemical sensing", SPIE Proceedings, Los Angeles, California, vol. 2118, p 72, (Jan 1994).

KEYWORDS: Point Detection, Chemical Detection, Biological Detection, DISC, DIAL, LWIR

A08-T025 TITLE: Bi-spectral (Visible & Infrared) Material for Smoke/Obscurant Munitions

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a bi-spectral smoke/obscurant material that will obscure in the visible and infrared regions of the electromagnetic spectrum. This material will form an obscuring screen for the protection of soldiers and platforms against visible and infrared threats (heat seeking missiles, thermal viewer, laser guided missiles, sniper fire, etc.).

DESCRIPTION: In the history of smoke and obscuration in the US military, there has not been any development of an obscuring material that would work in both the visible and infrared regions of the electromagnetic spectrum. The military uses separate munitions for each region of the spectrum; for the visible region, we use the L8 grenade, AN HC grenade, titanium dioxide hand grenade and the M76 smoke generator, for the infrared region, we use the M76 launched grenade. There are many scenarios where having one type of munition for both the visible and infrared regions is desirable. Bi-spectral capabilities are preferred by the Infantry School and are endorsed by the Joint Program Manager (JPM) Reconnaissance and Platform Integration. Bi-spectral efforts are in development in foreign countries (United Kingdom and France). The United States Army has been actively pursing a bi-spectral material to replace its existing payload material (JPM Reconnaissance & Platform Integration and JPM Close Combat Systems). The material should be effective in both the visible and infrared regions, with an extinction coefficient value (a measure of the screening/obscuring performance) equal or greater than that for the current material, which is 5 m2/g.

PHASE I: During Phase I, new and advanced materials will be developed. Intensive chemistry and material science will be needed to fabricate an effective material. Updated technologies and breakthroughs in vapor phase synthesis and nanotechnology may assist in developing a successful material. Material samples (approximately 50 grams) will be provided to the US Army for evaluation in an aerosol test chamber. The screening performance/ extinction coefficient will be measured and, based on the results, several candidate materials will be transitioned to Phase II. The objective of Phase I is to find or develop several high performing bi-spectral materials.

PHASE II: The objective of Phase II will be to obtain the material from Phase I and develop the material in a production scale, load the materials in munitions, and test in a controlled and real life environment.

PHASE III: The technology developed in this STTR will fill requirements set by the US Army for improved obscuration materials for use in grenades, mortars, and generators.

REFERENCES:
1. Dr. Janon Embury, “Maximizing Infrared Extinction Coefficients for Metal Discs, Rods, and Sphere", ECBC - TR-226, February 2002.

2. Batishko, C.R. ; Craig, R.A. ; Stahl, K.A. ; Salomon, L.L. ; Bodrero, D., “An infrared simulator for testing electro-optical systems against smoke and obscurants”, PNL-SA-15738;CONF-880489-1, January 1988.

3. Richard E. Hayes & Ronald C. Passmore, “Perspective on Multispectral Missile Seekers”, GACIAC Bulletin Volume 19 No. 2, June 1996.

KEYWORDS: obscuration, infrared screening, visible smokes

A08-T026 TITLE: Advanced Algorithms For A Combined Chem-Bio Standoff Sensor

TECHNOLOGY AREAS: Chemical/Bio Defense, Information Systems

OBJECTIVE: We are seeking algorithms for standoff chemical aerosol detection and novel algorithms that will significantly improve probability of detection and false alarm rate for both chemical and biological agents in the presence of chemical and/or biological interferents by use of orthogonal data sets from differential absorption and differential scattering . It is also an objective to demonstrate the success of these new algorithms with synthetic and actual field data obtained with a carbon dioxide (CO2) laser-based standoff sensor.

DESCRIPTION: Prior work with the FAL (Frequency Agile Laser) sensor has shown that DIAL in the LWIR is very effective in detecting and identifying chemical agent vapor in the atmosphere.(1,2) There is also recent evidence that chemical aerosols may be detectable by DISC in the LWIR. Furthermore, a breakthrough was recently achieved that showed biological agents can be detected and identified by DISC also in the LWIR.(3-4) This important finding shows that it is possible to perform both chemical and biological agent detection and identification with a single, CO2 laser-based standoff sensor. This has enormous benefits in terms of procurement cost and deployment logistics compared to the present situation where two sensors using widely differing phenomenologies are required.

There is a need for (1) chemical aerosol detection algorithms based on DISC, (2) algorithms that can combine orthogonal data sets for DIAL and DISC in the likely case of mixtures of chemical vapors and aerosols, (3) detection algorithms for both chemical and biological agents in the presence of both vapor and aerosol interferents, (4) methods to process DIAL and DISC data collected simultaneously to achieve rapid realtime output, and (5) analysis to show the specific sensor changes required to take full advantage of the new algorithm developments.

The data base for biological aerosol DISC has received a great deal of attention in recent years; but it is far from complete, especially as concerns interferents. The chemical aerosol data base is scant and requires significant development, including the signatures based on the complex index of refraction. Chemical aerosol DISC is an important phenomenology, because it is highly likely that chemical agent dissemination will include mixed aerosols and vapor. In that case, both DIAL and DISC could be used as orthogonal data sets to reduce the false alarm rate as well as afford a range-resolved chemical measurement which is not now possible by vapor DIAL. Further investigation is required.

PHASE I: Evaluate the state of the art of algorithms for standoff chem and bio detection and identification by DIAL and DISC. Provide recommendations for significantly improving algorithms. Outline an approach for development of chemical aerosol detection algorithms by DISC. Provide an approach for combining DIAL and DISC phenomenologies to achieve improvement in probability of detection and false alarm rate. Develop a roadmap for integrating algorithms for real time capability. Develop methods for algorithm validation using synthetic and real field test data, and develop a field test plan using the FAL sensor. Evaluate the implications of the new algorithms for laser and sensor design.

PHASE II: Use the findings of Phase I to develop advanced algorithms for biological aerosols, mixed chemical vapors and aerosols, and for these cases with interferents. Develop the fundamental complex index of refraction data base to support algorithm development. Validate the algorithms using synthetic and real field test data. Develop detailed recommendations and a roadmap for laser and sensor modifications necessary to make full use of the new algorithms.

PHASE III DUAL-USE APPLICATIONS: In Phase III, the novel algorithms and sensor recommendations can be used as a basis for development of prototype field test sensors. This will provide a much needed basis for evaluation by the military of new sensor concepts and it will reduce the risk in their development. This work will lead to a combined chem-bio sensor suitable for deployment on a number of platforms. Development of such a sensor would be of great benefit in homeland defense applications and for environmental pollution monitoring.

REFERENCES:

1. D. Cohn, J. Fox and C. Swim, "Frequency agile CO2 laser for chemical sensing", SPIE Proceedings, Los Angeles, California, vol. 2118, p 72, (Jan 1994).

2. “Extended Kalman filter for multiwavelength differential absorption lidar”, R. Warren and R. Vanderbeek, Proceedings of the SPIE 15th Annual International Symposium on Aerospace/Defense Sensing, Simulation, and Controls, April 2001,

3. R. E. Warren, “Discriminating Aerosols By Multi-Wavelength Lidar¨, Proceedings Sixth Joint Conference On Standoff Detection For Chemical and Biological Defense, Williamsburg, VA October 25-29, 2004,

4. R. Vanderbeek, R. Warren, and J. Ahl, “LWIR differential scattering discrimination of bio aerosols”, 7th Joint Conference On Standoff Detection For Chemical And Biological Defense, Williamsburg, VA, Oct 2006.

KEYWORDS: LIDAR, Algorithms, DISC, DIAL, chem/bio Sensor, standoff detection

A08-T027 TITLE: Super Hardened, EMI and Vibration Immune Chemical Biological Sensor

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: Develop a super-hardened chemical biological (CB) sensor that is sensitive, selective, low false alarm rate, immune to electromagnetic interference (EMI) and vibration, which can be dropped from airplane and has an estimated end item cost of less than $100 per unit.

DESCRIPTION: The Joint Services have the need for affordable, wide area monitoring, detection and alarm for presence of chemical agents, biological agents and toxic industrial chemical and materials. A popular and recurring monitoring scheme is a distributed sensor net that can monitor a geographical region of interest. Sensor deployment of a distributed network of sensor may be accomplished by dropping sensors without a parachute from airplane to monitoring site. Such sensors would need to be super-hardened to survive. Available sensors, such as infrared spectrometers and mass spectrometers provide the desired sensitivity and selectivity, but they are fragile and too expensive to deploy in a many-sensor distributed network. New technologies and methods developed and leveraged from the telecommunications industry provide the promise of creating new sensors with the sensitivity and selectivity of large spectrometers with the small footprint and price of commodity computer chips. Utilizing the unique physical properties of mass on the micro and nano scale, MEMS/MOEMS (Micro (Opto) Electro Mechanical Systems and NEMS (Nano (Opto) Electro Mechanical Systems may provide systems that are immune to vibration and EMI.

The goal of this program is to develop a MEMS scale monolithic optical sensor that can be dropped from an airplane with an estimated end item cost of less than $100 per unit. The system should be immune to vibration and EMI while providing sensitivity and selectivity comparable to a laboratory fourier transform infrared spectrometer (FTIR). The sensor should run on standard batteries without an outside power source.

PHASE I: Design and build a small monolithic optical sensor breadboard. Utilize simulation to demonstrate predicted ability of the sensor to survive air drop without a parachute. Examine vibration and EMI characteristics of the proposed sensor. The goal of this effort is to develop a sensor that can detect the vapor of a simulant such as triethylphosphate at concentrations of less than 0.1 milligram per cubic meter. Collect breadboard data to determine sensitivity and selectivity performance with Receiver Operating Characteristic Curves (ROC curves) or equivalent experimental/statistical method. Currently, the Telecom-based optical devices utilizing silicon have spectral ranges from100 nanometers to 3.5 or 3.6 micron. Explore methods, techniques and materials to widen the spectral range of MEMS/NEMS based optical sensors from 2 to 22 microns.

PHASE II: Fabricate a sensor brass board based from the Phase I design. While the brassboard need not meet the final size and weight constraints, a clear and practical analysis indicating the path from brassboard to prototype should be defined with weight, power and size limit goals by major subsystem.. Measure the sensitivity to selected simulants and establish the limiting noise source. Using a recognition algorithm of choice, determine the variance possible in wavelength and amplitude vs. false alarm rate. The sensor should run on standard batteries without an outside power source

PHASE III DUAL USE APPLICATIONS: There are many environmental applications for a small ultrasensitive, chemical detector/identifier. A rugged, ultrasensitive and flexible chemical detector will benefit the manufacturing community by providing very finely tuned monitoring of chemical processes. Also first responders such as Civilian Support Teams and Fire Departments have a critical need for a rugged, relatively inexpensive but versatile and rugged sensor that can be transported to the field to test for possible contamination by CW agents. The potential for short-range standoff enhances this utility.

REFERENCES:
1. J. Reid, M. El-Sherbiny, B. K. Garside, and E. A. Ballik, "Sensitivity limits of a tunable diode laser spectrometer, with application to the detection of NO2 at the 100-ppt level," Appl. Opt. 19, 3349- (1980).

2. D.D. Nelson, J.H. Shorter, J.B. McManus, M.S. Zahniser, “Sub-part-per-billion detection of nitric oxide in air using a thermoelectrically cooled mid-infrared quantum cascade laser spectrometer”, Journal Applied Physics B: Lasers and Optics, Issue Volume 75, Numbers 2-3 / September, 2002, Pages 343-350.

3. J. Podolske and M. Loewenstein, "Airborne tunable diode laser spectrometer for trace-gas measurement in the lower stratosphere," Appl. Opt. 32, 5324- (1993).

4. M. Nägele, M.W. Sigrist, “Mobile laser spectrometer with novel resonant multipass photoacoustic cell for trace-gas sensing”, Journal Applied Physics B: Lasers and Optics, Issue Volume 70, Number 6 / June, 2000, Pages 895-901

5. Gaura, Elean; Newman, Robert, Smart MEMS and Sensor Systems, Imperial College Press, Covent Garden, London; ISBN 1-86094-493-0, 2006.

6. Motamedi, Manouchehr E.; MOEMS Micro-Opto-Electro-Mechanical Systems; SPIE Press, Bellingham, Washington, USA; ISBN 0-8194-5021-9; 2005

7. J.W Judy, “Microelectromechanical systems (MEMS): fabrication, design and applications”, Smart Mater. Struct. 10, pp. 1115-1134, 2001.

8. D.A. Cohen, E.J. Skogen, H. Marchand, and L.A Coldren, “Monolithic chemical sensor using heterodyned sampled grating DBRlasers”, Electronics Letters, Volume: 37, Issue: 22 , pp.1358-1360, 2001.

KEYWORDS: Chemical Detection, tunable laser, MEMS, MOEMS, optical MEMS, Infrared spectrum

A08-T028 TITLE: Development of a Fire-Resistant, Thermal Barrier Coating with Low-Temperature Flexibility

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a thermal barrier coating to cost-effectively protect critical infrastructure components from catastrophic failure due to high-intensity heat or direct flame. The coating must be able to protect a variety of common substrate materials including metals, masonry, wood, and plastics (polymers) used in construction. The coating must also resist cracking, flaking, and debonding during exposure to extreme weather, intensity sunlight (i.e., ultraviolet radiation), corrosive environments (e.g., salt spray), and mechanical deformation such as bending and twisting, even at very low-temperatures.

DESCRIPTION: Thermal barrier coatings are used to protect critical structural members, such as beams and columns in a building or bridge, from catastrophic failure in the event of a fire or extreme heat condition. With increasing use of polymeric composites in the construction of facilities and critical structural components, and given the combustibility of most of these polymeric materials in a direct fire situation, thermal barrier coatings could be a cost effective solution to reducing the risk of these materials when subjected to direct flame of becoming directly involved in the fire thus adding to the fire intensity. A recent study showed that current commercially available thermal barrier coatings have, in some cases, marginal resistance to a direct flame and most have poor low-temperature flexibility (1).
A thermal barrier coating is therefore needed that will: (1) withstand a direct flame at 2,835 degrees Fahrenheit (propane in air) for ten (10) minutes while keeping the substrate from reaching a temperature above 500 degrees Fahrenheit; (2) remain flexible at -110 degrees Fahrenheit when bent over a quarter-inch mandrel, (3) adhere to steel, aluminum, wood, and polymeric construction materials, and (4) resist deterioration due to weathering, intense ultraviolet (UV) radiation, and corrosive environments (e.g., salt-spray) The coating system must be able to be applied by spray, by brush or roller, and by dipping.

The Army has demonstrated interest in such a thermal barrier coating, if commercially available, to protect steel munitions cases as shown by a study funded by the Armament Research, Development and Engineering Center (ARDEC) in Picatinny Arsenal, NJ, comparing properties of commercially available thermal barrier coatings to a conceptual glass fiber reinforced, silicone-based coating (2). If successfully developed and commercialized, applications on military vehicles and weapon systems where high heat is generated are also envisioned. Use of this coating by the private sector for the fire protection of critical structures would be a high probability. Such a coating would provide a cost effective means for protecting critical structural components for the effects of high heat and flame, whether accidental or intentional (e.g., acts of vandalism, arson, or terrorism).

The program must include a research plan that will lead to the development of a flame-resistant, thermal barrier coating with low-temperature flexibility and durability to all types of exposure use environments. The program will incorporate a detailed test plan to thoroughly evaluate the properties of the coating per the performance criteria described above. Variations in the formula as needed for the different application techniques must also be tested against the same performance requirements. Finally, the program must develop a feasible plan for the manufacturing and commercialization of the new thermal barrier coating.

PHASE I: For Phase I, the commercial and research/academic Team shall investigate and demonstrate innovative and cost effective materials to achieve thermal barrier coatings that can withstand direct flame while maintaining coating integrity and protection of the substrate to excessive heat. The Team shall demonstrate that any such thermal barrier coating will be flexible at extreme low temperatures, resisting cracking, flaking, and debonding when subjected to bending at these extreme low temperatures. The Team shall also develop prototype formulations for application by brush or roller, spraying, and dipping.

PHASE II: In Phase II, the Team shall implement testing of the prototype formulations to determine durability to weathering and other corrosive environmental exposure conditions. With the help of the research/academic partners, the commercial, private sector partner shall implement the manufacturing of the successful prototypes and conduct full-scale testing and limited-scale demonstrations of the thermal barrier coatings on a variety of infrastructure components to include steel, aluminum, wood, and polymers with particular interest in reinforced high-density polyethylene based structural-grade plastic lumber. The private sector, commercial partner shall explore costs of full production and the cost benefits associated with the use of the new, innovative thermal barrier coatings.

PHASE III: Manufacturing the coating is not expected to be difficult nor is it expected to require exotic equipment or processing techniques. Applications for the thermal barrier coating include military infrastructure facilities as well as military equipment and logistical support components. Private sector applications would include, but not limited to: structural members in buildings and critical structural members in bridges. The commercialization phase will include full-scale demonstrations of the thermal barrier coatings on facilities to include different substrate materials. Full-scale production and marketing will be implemented by the commercial private sector partner.

REFERENCES:

1. Lynch, J.K., T. Nosker, D. Ondre, M. Mazar, and P. Nosker, "Development of a Composite Thermal Barrier Coating," Proceedings, Society of Plastics Engineers Annual Technical Conference, May 2007, Cincinnati, OH.

2. Nosker, T.J., et. al., "Thermal Management of Packaged Munitions," unpublished letter report from the Advanced Materials via Immiscible Polymer Processing (AMIPP) Center at Rutgers University, NJ, to the Armament, Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, NJ, November 2006.

KEYWORDS: thermal barrier, coating, fire resistant, combustibility, infrastructure, low-temperature, durability

A08-T029 TITLE: Nanoscale In-Solution TEM Sample Stage With Manipulation Capability

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a Transmission Electron Microscopy (TEM) sample stage that provides the ability to image and manipulate samples in solution at the nanometer scale.

DESCRIPTION: The current ability to image at the nanometer scale using TEM is confined to dry samples given the vacuum conditions required. This limitation means that TEM images related to any process under investigation that occurs in solution (e.g., water or otherwise) are, in effect, an inference or approximation of the actual process. The possible effects of wetting/surface tension, solvation, absence of agglomeration, in-solution differences in molecular conformation, and others, are not covered. Within a number of quickly developing fields (e.g., nanotechnology using Carbon Nano-Tubes (CNTs), genetic engineering, synthetic biology, Nano-scale Electro-Mechanical Systems (NEMS), nano-fluidics, and, nano-sensors) progress is significantly hampered by the inability to see and manipulate at the nanoscale while in solution.

PHASE I: The Phase I effort shall result in the ability to image nanoscale samples in solution using a conventional TEM. The sample stage developed from this work should be easily usable, cost effective, and not require excessive preparation time for each sample (i.e., 20 minutes or less). Attention will also need to be paid to image quality and means to avoid distortion or sample movement from localized beam heating.

PHASE II: The results from Phase II shall in addition include the ability for limited direct manipulation of in-solution samples while TEM imaging is ongoing. This could involve causing the movement of molecules toward or away from each other, localized cooling or heating, localized pH modification, the introduction of voltage gradients and/or magnetic fields, or other means of manipulation appropriate for various research questions. Once again localized beam heating and degradation of image quality will need to be minimized and/or otherwise managed appropriately.

PHASE III DUAL USE APPLICATIONS: As an enabling technology multiple dual use applications are possible. The fields of microbiology/virology, genetic engineering, and synthetic biology should also be applicable. The area of drug development (i.e. real time cellular level drug interaction) could also benefit.

REFERENCES:
1. Microstructure of Fine-Grained Sediments From Mud to Shale, Springer-Verlag, New York, 1991 (ISBN: 0387973397): Chapt. 36 "Observation Technique for Wet Clay Minerals Using Film-Sealed Environmental Cell Equipment Attached to High-Resolution Electron Microscope".

2. Won, You-Yeon, "Imaging Nanostructured Fluids Using Cryo-TEM", Korean J. Chem. Eng, Vol 21, No. 1, pp. 296-302.

KEYWORDS: TEM, imaging, wet-TEM, in-solution, manipulation, nanoscale, nanotechnology, genetic engineering

A08-T030 TITLE: Straight Vegetable Oil Modification for Combustion

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To develop a simple and inexpensive means to reformulate and/or modify straight vegetable oil so as to allow wide spread use for use in boilers and for other combustion applications.

DESCRIPTION: The use of renewable fuels such as straight vegetable oil (SVO) has the potential multiple benefits of: energy security, improved economic competitiveness, decreased maintenance, improved sustainability, and greenhouse gas emission reduction. While biodiesel processing (i.e., trans-esterfication) is one alternative the extra energy inputs, processing costs and waste streams produced all serve as drawbacks to implementation. To help promote the use of SVO for fixed boilers and other applications the viscosity properties need to be modified and/or reformulated to better match existing equipment such as injector nozzles and feed piping systems. The effects of temperature also have to be accounted for and addressed to assure reliable combustion.

PHASE I: The Phase I effort shall result in a proof of principle for the proposed modification approach. Assessment shall include types/classes of SVO oil for which it is applicable for, resulting viscosity properties as modified for a range of temperatures, a full characterization of combustion properties, a detailed scaled up economic analysis of the SVO modification method as implemented and in comparison to alternatives, as well as any other factors related to the likely ultimate implementation and success of the technology. Phase I results shall also include the experimental plan for Phase II extended trial implementation.

PHASE II: The Phase II effort shall consist of a long term demonstration of burning SVO, as modified by the subject developed technology, in a typical and well instrumented working boiler. Performance metrics measured for the entire range of operation shall include consumption rate, energy output, effects on maintenance tasks/costs, detailed economics (production and use), resulting space heating comfort compared to conventional fuels (objective and subjective measures), any storage or delivery aspects, and the effects on greenhouse gas emission reduction (and any other emissions such as particulate matter), both for combustion alone and for the entire process from start to finish. Independent third party verification of the most critical performance factors shall be employed.

PHASE III DUAL USE APPLICATIONS: Another dual use application that would also help support energy security is the use of modified SVO as a fuel for diesel engines. In this application the starting characteristics, especially in cold weather, become critical. The emission of particulate matter also is factor that would need to be vigorously addressed.

REFERENCES:
1. Goodrum, John W. et al. “Rheological characterization of animal fats and their mixtures with #2 fuel oil,” Biomass and Bioenergy, 24 (2003) 249-256.

2. Dunn, R.O., “Low-Temperature Flow Properties of Vegetable Oil/Cosolvent Blend Diesel Fuels,” JAOCS, Vol. 79, no. 7 (2002) pp. 709-715.

3. Sharma, H.O., et al., “Miscibility Studies of Polyesteramides of Linseed Oil and Dehydrated Castor Oil with Poly(vinyl alcohol),” Intl. J. of Polymeric Materials, 56: 437-451, 2007.

KEYWORDS: SVO, viscosity, combustion, boiler injection

A08-T031 TITLE: <u>Scalable and Deployable Microgrids</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop an “intelligent” decision and control architecture for an electric power distribution network that allows “plug-and-play” interconnection of a diverse range of distributed generation (DG) technologies, energy storage equipment, and the critical loads that are served, into a readily scalable and deployable microgrid.

DESCRIPTION: The most significant technical challenges in developing this capability will be in addressing the network science issues of control architecture, self-healing/auto-reconfiguring distribution topologies, and agent-based data communication protocols. Ideally, the capability will allow “plug-and-play” interconnection of both intelligent DG sources, including energy storage technologies, and intelligent loads; so available power at any point in time is delivered to the prioritized critical loads during that same instant in time.

The scalable, deployable microgrid will be used for both Forward Operating Base (FOB) and Tactical Operations Center (TOC) applications. In addition, the microgrid concept can also be used to rapidly restore power to an existing utility grid that has lost power, due to damage to the main central power plant and/or surrounding regional grid, whether by natural disaster, terrorist attack, or combat objective. Until the damage to the existing equipment can be repaired, this capability would allow reconstruction personnel to move in with a diverse array of DG assets, including conventional engine-driven generators, advanced DG technologies like fuel cells and microturbines, and renewable energy technologies like wind, solar, geothermal, and biomass; interconnecting them with the de-energized local grid and creating an “islanded” intelligent microgrid. This, in turn, will encourage the expanded use of these more sustainable, advanced energy technologies and decrease reliance on foreign energy sources.

PHASE I: The Phase I effort shall result in a proof of principle for the proposed “intelligent” microgrid decision and control architecture. Modeling and simulation of the scalable/deployable microgrid and how the control architecture is capable of reliably delivering power to the critical loads, while maintaining grid stability, will be a necessary part of this work. Phase I results shall also include the experimental plan for a Phase II extended trial implementation.

PHASE II: The Phase II effort shall consist of a FOB-level “bench test” demonstration of the microgrid decision and control architecture, to determine how well it performs. Independent third party verification of the most critical performance factors shall be employed.

PHASE III DUAL USE APPLICATIONS: As mentioned above, the scalable/deployable microgrid capability can be used as a “ground up” utility grid restoration approach, when an existing power grid has been damaged by natural disaster, terrorist attack, or combat objective. Logical potential dual-users would be the Department of Homeland Security, the Federal Emergency Management Agency, and the Restore Iraqi Electricity effort.

REFERENCES:
1. T. Abdallah, R. Ducey, R. Balog, C. Feickert, W. Weaver, A. Akhil, D. Menicucci; “Control Dynamics of Adaptive and Scalable Power and Energy Systems for Military Microgrids”; a Special Report of the U.S. Army Engineer Research and Development Center - CERL, 2006.

2. D. Menicucci, R. Ducey, and P. Volkman; "Energy Surety for Mission Readiness", Public Works Digest of the U.S. Army Installation Management Agency, Volume XVIII, No. 2, March/April 2006

KEYWORDS: microgrid, distributed generation, network science, control architecture, self-healing/auto-reconfiguring distribution topologies, agent-based data communication protocols, “plug-and-play” interconnection, energy storage technologies, intelligent electrical loads

A08-T032 TITLE: Aerosol Decontaminant for Use in Patient Care Areas

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop EPA (Environmental Protection Agency)-approved antimicrobial aerosol to reduce reservoirs of nosocomial pathogens on all surfaces in clinics and hospital wards, including combat support hospitals; dispersed via single-use canister or multi-use aerosol generator.

DESCRIPTION: Nosocomial transmission of multi-drug-resistant microorganisms is a well-recognized and growing problem at healthcare facilities worldwide. The problem is particularly severe in Combat Support Hospitals because (1) space is often limited relative to the number of patients, resulting occasionally in overcrowded conditions, (2) the materials used in constructing the hospital are chosen for their rapid deployability or ready availability, not necessarily for their resistance to bacterial colonization, (3) infection control practices and isolation procedures are difficult to implement in a combat environment, (4) trauma and burn victims have compromised barriers to infection.

Therefore, a rapid, simple and safe method for decontaminating a hospital ward has the potential to be part of a multifaceted approach to reducing nosocomial infection in this setting.

Antimicrobial pesticides delivered as an aerosol have the potential to thoroughly coat and penetrate niches where bacterial reservoirs would otherwise escape standard housekeeping procedures. Delivery mechanisms for pesticide fumigants have already been developed. The major research effort, therefore, will be focused on the discovery or development and testing of an appropriate decontaminant chemical.

The decontaminant chemical must (1) be non-toxic if touched, inhaled in small concentrations (such as would be encountered in adjacent rooms or if entering the treated room within minutes of aerosol delivery), or ingested in small quantities (ie, the residual left on a drinking cup left in a treated room minutes after treatment), (2) not damage computers or precision electrical devices in the treated room, (3) not promote the development of microbial resistance to antibiotic medications, (4) not require hermetic isolation of the treated room to be safe or effective, (5) not pose a threat to the environment, either due to accumulation in the soil or theoretical depletion of ozone, (6) remain stable at the temperature and pressure extremes encountered in transportation to and storage in austere locations worldwide.

It is not expected that the aerosol would be dispersed in an inhabited room. The primary target of decontamination is microbial pathogens; it is not expected that the aerosol would be effective against arthropod or rodent pests. It is not expected that treated rooms would be completely sterile, only that reservoirs of nosocomial pathogens would be reduced to the point that transmission would be significantly reduced. Either single use canisters or multi-use aerosol generators would be acceptable prototypes; both delivery mechanisms would likely fill marketable roles eventually.

The product should be developed with the intention of eventually meeting EPA registration requirements.

PHASE I: Identify or develop candidate antimicrobial pesticides. Develop method for testing efficacy, demonstrate efficacy against common nosocomial organisms; identify methods for testing safety in accordance with EPA regulations.

PHASE II: Down-select from candidate pesticides one or more for further development. Develop a prototype delivery method or methods and characterize the resulting concentration delivered per unit time and dimensions of treated room. Conduct safety and efficacy testing in accordance with EPA regulations.

PHASE III: Produce safe and effective EPA-registered product. Develop market in fixed military treatment and civilian healthcare facilities.

REFERENCES:
1. Scott P, Deye G, Srinivasan A, Murray C, et al, An outbreak of multidrug-resistant Acinetobacter baumannii-calcoaceticus complex infection in the US military health care system associated with military operations in Iraq, Clin Infect Dis 44:1577-84, 2007.

2. Wilks M, Wilson A, Warwick S, Price E, Kennedy D, Ely A, Millar MR, Control of an Outbreak of Multidrug-Resistant Acinetobacter baumannii-calcoaceticus colonization and infection in and intensive care unit (ICU) without closing the ICU or placing patients in isolation, Infec Cont Hosp Epi, 27(7): 654-8, 2006.

3. Clark J, Barrett SP, Rogers M, Stapleton R, Efficacy of super-oxidized water fogging in environmental decontamination, J Hosp Inf 64: 386-90, 2006.

4. Kramer A, Schwebke I, Kampf G, How long do nosocomial pathogens persist on inanimate surfaces?, BMC Infect Dis, 6:130, 2006.

KEYWORDS: Environmental decontamination, nosocomial infection, combat support hospital.

A08-T033 TITLE: Bioinformatic Based Wearable Critical Care Monitor

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop a small wearable device which collects low level physiologic signals and then uses bioinformatic approaches to provide physiological status metrics during progressive reductions in central blood volume, thereby providing a future capability for real-time assessment of hemorrhage in trauma patients.

DESCRIPTION: Hemorrhagic shock from trauma continues to be the primary cause of death on the battlefield. Most medical monitors that are currently used to ascertain the physiological status of hemorrhaging trauma patients are unsuitable for battlefield use. Furthermore, most are designed only to collect and report discrete physiologic data, most of which cannot be collected prior to injury and therefore have limited value. Finally, these data are mostly confined to standard vital signs (e.g., blood pressure, heart rate) that have dubious value in assessing the severity of hypovolemic states. Because of these issues, military scientists have been investigating the applicability of new vital signs (e.g., heart rate variability) and new monitoring systems which will allow continuous remote triage capabilities (e.g., the Warfighter Physiological Status Monitor).

Few if any current monitoring systems incorporate bioinformatic approaches to data analysis. Sophisticated computational techniques exist which, when applied to simple low level physiologic signals such as temperature, movement, and heart rate, are capable of producing remarkably accurate predictions of seemingly unrelated variables such as oxygen consumption or pulse pressure. Specifically, the use of supervised machine learning techniques holds the promise of transforming easily obtained lower level signals into useful information that may be used for acute assessment of the injured warfighter. Briefly, the process of supervised machine learning is the building of a model in some chosen representation (such as an artificial neural network, a decision tree, or a probabilistic network). Input signals are first collected in the presence of the outputs to be predicted by the model being learned. Statistical machine learning techniques are then used to create, train, or 'learn' a model such that the model accurately relates the inputs to the known outputs in this training set. These techniques often search through possible model frameworks to find the best one. The models are compared using methods such as statistical bootstrapping and cross-validation, which measure the ability of the model to generalize to unseen data. After the best model is selected, it is evaluated on a completely unseen set of data. Such a supervised machine learning approach has been applied to a number of modeling questions, to include state modeling for body states such as sleep or activity level. The objective of this topic is to apply these computational techniques to physiologic data that are easily obtained in the battlefield, with the eventual output of physiological parameters that may be useful for the real-time triage of combat casualties.

PHASE I: Proof-of-concept that collection of easily obtained low level body signals such as skin temperature, heat flux, heart rate, etc., when subjected to bioinformatics approaches, produce physiologic parameters that may be useful for the real-time diagnosis and treatment of injured warfighters. These physiologic parameters may include but not be limited to mean arterial pressure, pulse pressure, shock index, oxygen consumption, oxygen debt, tissue oxygenation and blood flow. Futhermore, the bioinformatics approach will incorporate context into the analysis which may include, for example, the activity and/or metabolic level of the warfighter prior to injury.

PHASE II: Optimization of data collection and analysis will be tested in suitable laboratory animal models as well as in humans during hemorrhage simulation and/or during actual transport to a hospital in an evacuation vehicle. Evaluation of data quality and consistency will be conducted.

PHASE III DUAL USE APPLICATIONS: A device capable of providing near real-time estimates of injury severity would assist combat and civilian medics in triage prioritization and intervention decision early in the progression of injury. An added benefit of this approach is that information could theoretically be generated from a remote location before a medic even reaches a casualty. Such a device could save lives by providing critical information on injury severity, and should be of great commercial interest for all branches of the U.S. armed services as well as trauma units around the world. There would also be great utilization of such devices for monitoring of patients in emergency departments, operating rooms, and intensive care units.

REFERENCES:

1. Aminian et al; (1995): Estimation of speed and incline of walking using neural networks. IEEE Transaction on Instrumentation and Measurement, 44 (3): 118-125.

2. Cole, P.J., LeMura, L.M., Klinger, T.A., Strohecker, K, McConnell, T.R. (2004). Measuring energy expenditure in cardiac patients using the BodyMedia™ armband versus indirect calorimetry. A validation study. Journal of Sports Medicine and Physical Fitness 44:262-271.

3. Cooke WH, Convertino VA. (2005). Heart rate variability and spontaneous baroreflex sequences: Implications for autonomic monitoring during hemorrhage. J Trauma 58: 798-805.

4. Eston RG; Rowlands AV; Indedew DK. (1998): Validity of heart rate, pedometry and acceleromety for predicting the energy cost of children's activities. Journal of Applied Physiology, 84 (1): 362-371.

5. Savell CT, Borsotto M, Reifman J, Hoyt RW. (2004): Life sign decision support algorithms. Medinfo 11: 1453-1457.

6. Wadsworth, D.D., Howard, T., Hallam, J.S., Blunt, G. (2005): A Validation Study Of A Continuous Bodymonitoring Device: Assessing Energy Expenditure At Rest And During Exercise, Medicine & Science in Sports & Exercise: Volume 37(5) Supplement May 2005 pS24

KEYWORDS: monitor, warfighter, machine learning, bioinformatics, critical care

A08-T034 TITLE: Robotic Standoff Neck and Spinal Injury Assessment Device

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: The objective of this topic is to design and develop an autonomous or teleoperated injury assessment device that can detect and diagnose traumatic spinal and neck injuries and other fractures which could be further aggravated during casualty extraction or evacuation.

DESCRIPTION: The Army is currently developing several robotic systems for extraction of casualties from hostile environments and from under fire. Prior to employing a robot to rescue a wounded soldier, the medic operator has to know whether the casualty has sustained neck, spinal, or other injuries that could be exacerbated by robotic extraction. Significant research and development efforts are underway within the US Army Medical Research and Materiel Command (USAMRMC) and the Future Force Warrior Program to develop the Warrior Personal Status Monitor (WPSM) as a device for remote triage on US troops. As currently designed, the WPSM cannot detect head, neck, spinal, chest or limb fractures unless they result in measurable physiological symptoms. Likewise, many of the casualties treated by US forces during current and future asynchronous peacekeeping and counterinsurgency operations will not be American soldiers and will not be wearing a WPSM, even in the future. Therefore a remote sensor array which is not dependent upon the casualty wearing a monitor is needed for detection of fractures. Diagnosis of spine and neck injuries in the field is difficult especially on unconscious patients and will probably require some kind of ruggedized portable imaging system which can implemented via JAUS (Joint Architecture for Unmanned Systems) on one or more of the emerging military rescue robots. Several technologies are potential candidates for this research topic. Non-ionizing technologies are preferred; these could potentially include C-mode ultrasound, mid-IR (infrared) thermal imaging with near-IR reflection spectroscopy or microwave imaging (radar). Since combat medics are normally not trained in interpreting ultra-sound or IR images, use of this technology to identify potential spine and neck injuries will require implementation of computerized interpretation of images via a pattern matching algorithm. In addition to the diagnostic imaging and pattern matching analysis technologies, research challenges inherent in this topic include sensor array power management, miniaturizations, ruggedization, image processing and presentation, JAUS communication and robot integrations. For example, image processing and analysis is best performed on the robot itself rather than on the Operator Control Module (OCM) in order to facilitate future autonomous operations, and communication of both images and command and control of the sensor to the user OCM must be through the robot's JAUS enabled command and control system.

PHASE I: Conceptualize and design a prototype wireless autonomous or teleoperated injury assessment device that can detect and diagnose traumatic spinal and neck injuries and other fractures for implementation via the Joint Architecture for Unmanned Systems (JAUS) on combat casualty extraction robots currently being developed under the Army-Marine Corps Ground Robotics Master Plan and the DOD Unmanned Systems Roadmap. Preliminary study is desired to demonstrate the potential of the device for diagnosis of traumatic spinal and neck injuries and other fractures, Develop a research plan for Phase II.

PHASE II: Develop, integrate and demonstrate a prototype wireless autonomous or teleoperated injury assessment device that can detect and diagnose traumatic spinal and neck injuries and other fractures for implementation via the Joint Architecture for Unmanned Systems (JAUS) on combat casualty extraction robots currently being developed under the Army-Marine Corps Ground Robotics Master Plan and the DOD Unmanned Systems Roadmap. Perform data/image acquisition, processing and analysis for diagnosis purposes and evaluate the system capability. Develop a commercialization plan for Phase III.

PHASE III: Assist the Army in transitioning and implementing via JAUS on combat casualty extraction robots, a prototype wireless autonomous or teleoperated injury assessment device that can detect and diagnose traumatic spinal and neck injuries and other fractures. Transition the integrated system to a program of record such as the Army Future Combat Systems (FCS). Develop and market a commercial version of the sensor for use by civilian emergency first responders with or without a robot.

REFERENCES:
1. Brower, J.M. “Vitality Signs”. Military Medical Technology. Aug 2004. 8(5):36-38.

2. Lo S-C.B., Liu C.C., Freedman M.T., Kula J., Lasser B., Lasser M.E., Wang Y., “Transmission and Reflective Ultrasound Images using PE-CMOS Sensor Array.” SPIE Proc. vol. 5750, pp. 69-76; 2005.

3. Appenzeller GN. Injury patterns in peacekeeping missions: the Kosovo experience. Mil Med. 2004 Mar;169(3):187

4. Hunter JD, Mann CJ, Hughes PM. Fibular fracture: detection with high resolution diagnostic ultrasound. J Accid Emerg Med. 1998 Mar;15(2):118.

5. JAUS Working Group: http://www.jauswg.org

6. Smuda, Wl, Software wrapper for rapid prototyping JAUS-based systems, in SPIE Proceedings Vol. 580-4, Unmanned Ground Vehicle Technology VII, Gerhart, G.R., C.M. Shoemaker, D.W. Gage, Editors, 2005 May; pp.718-726

7. Yifeng Jiang; Zhijun Zhang; Feng Cen; Hung Tat Tsui; Tze Kin Lau, An enhanced appearance model for ultrasound image segmentation, Pattern Recognition, 2004. ICPR 2004. Proceedings of the 17th International Conference on Volume 3, Issue , 23-26 Aug. 2004 Page(s): 802 - 805 Vol.3; http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/9258/29387/01334650.pdf

8) USAMRMC TATRC Robotic Casualty Extraction and Evacuation Program: http://www.tatrc.org/website_robotics/index.html

KEYWORDS: robot, sensors, medical diagnostic imaging, remote triage, neck and spinal fractures, combat casualty care, casualty extraction

A08-T035 TITLE: <u>Ante-mortem Diagnostics for Prion Infection</u>

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Development of novel reagents and methods for preclinical (ante-mortem) detection of prion infection in humans and in animals destined for human use.

DESCRIPTION: Transmissible Spongiform Encephalopathies (TSEs) are fatal neurodegenerative disorders associated with the accumulation of abnormal misfolded prion proteins in nerve cells. Historically, the initial diagnosis of TSEs was based on histopathologic changes in tissues, e.g., brain or lymphoid tissue after the death of an animal or person. Ten years have passed since the human prion disease variant Creutzfeldt-Jakob disease (vCJD), a form of TSE was reported for the first time, and the risks of humans acquiring TSEs via a variety of exposures to infected materials such as contaminated beef products have been acknowledged. However, no cure, prophylaxis, or fail-safe ante-mortem diagnostic test or assay for prion-related diseases is available to date. Military personnel traveling to foreign countries have no direct control over the source of food and run the risk of acquiring prion infection by consuming prion-contaminated food. Other sources of infection include prion-contaminated surgical instruments, infected tissues and organs from prion-infected donors, and contaminated blood products. As the disease is invariably fatal, an ante-mortem diagnostic test to detect prion infection before the onset of clinical symptoms is urgently needed.

The economic implications also are enormous as vast amounts of food and blood supplies are involved. Millions of cattle are slaughtered for beef and millions of units of whole blood are collected annually for transfusion in the United States. There is thus a tremendous potential for market as millions of animals and blood samples need to be tested for possible contamination. Ante-mortem detection of prion infection in animals and testing of blood products will prevent the spread of infection and culling of live stock.

The goal of this solicitation is to aid development of sensitive, specific, reproducible, and rapid ante-mortem diagnostic tests, e.g., development of an in vitro cell culture method for detection of prion infection. Use of new technologies such as proteomics, microarray technology, etc., is encouraged. Identification of new non-prion markers should be validated in a cell culture system for proof of concept. Development of new innovative techniques with substantial promise rather than marginal improvements of existing tools is expected. The new diagnostic method developed should be able to detect infection prior to the onset of clinical symptoms.

PHASE I: The objective of phase I is to develop a diagnostic method or agent for detecting prion infection in preclinical stage of the disease and to establish the proof of concept. The goal is to demonstrate the feasibility of detecting very low concentrations of misfolded prion proteins or any surrogate markers of prion infection in easily accessible biological samples from seemingly healthy individuals or animals. The reagents should be applicable to assessing the food and blood supply, analysis of animals at the time of slaughter, and screening of live animals. The use of animal and human subjects requires approval by the appropriate US Army Medical Research and Materiel Command regulatory office.

PHASE II: The objective of phase II is to validate the method of detection developed in phase I in patients and in animals suspected to be at risk. The detection method must be sensitive, specific, and reproducible. Once the method of detection is evaluated and found acceptable, a detailed commercialization plan for marketing the reagents must be developed and scale-up synthesis of reagents under GMP guidelines needs to be studied.

PHASE III: The objective of phase III is to establish collaborations and evaluate the methods in different human or animal populations suspected to be at risk, e.g., in areas where prion infections or related deaths have been reported earlier, and military personnel working in such areas, to identify real cases of prion infection. The commercialization potential of the newly developed reagents will be high in both military and civilian contexts. The studies should aim at marketing the technologies to pharmaceutical or biotech companies possessing the capability and infrastructure to complete the reagent kit development and obtaining required FDA approvals.

REFERENCES:
1. Prusiner SB. Prions. Proc Natl Acad Sci U S A. 1998 Nov 10;95(23):13363-83. Review.

2. Gavier-Widen D, Stack MJ, Baron T, Balachandran A, Simmons M. Diagnosis of transmissible spongiform encephalopathies in animals: a review. J Vet Diagn Invest. 2005 Nov;17(6):509-27.

3. Will RG, Ironside JW, Zeidler M, Cousens SN, Estibeiro K, Alperovitch A, Poser S, Pocchiari M, Hofman A, Smith PG. A new variant of Creutzfeldt-Jakob disease in the UK. Lancet. 1996 Apr 6;347(9006):921-5.

4. Parveen I, Moorby J, Allison G, Jackman R. The use of non-prion biomarkers for the diagnosis of Transmissible Spongiform Encephalopathies in the live animal. Vet Res. 2005 Sep-Dec;36(5-6):665-83.

KEYWORDS: Prion, ante-mortem, diagnostics, early detection, prevention, treatment.

A08-T036 TITLE: Automated Microscopic Malaria Diagnosis

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop high-throughput automation to assist in the detection and quantification of malaria parasites in human blood smears.

DESCRIPTION: Rationale: Historically, malaria has been one of the leading causes of soldier incapacitation during deployment. Thus, MRMC invests heavily in the invention and development of both drugs and vaccines for the treatment and prevention of malaria. Additionally, recent malarial outbreaks among soldiers have been plagued with late or inaccurate diagnosis due to misconceptions about soldier compliance with preventive measures and poor availability of well trained microscopists at point-of-care facilities. Unfortunately, the gold standard for malaria diagnosis and quantification, both for clinical diagnosis and for experimental clinical and field trials, remains the identification and counting of parasites in thick and/or thin blood films by trained operators. This technique, however, is limited in accuracy by technician training, by the number of microscopic fields a human can examine, and by operator fatigue. Efforts to improve the accuracy and control of this process have been only partially successful because of the insurmountable issues of microscope operator fatigue, human error and inattention (1,2); false negative and false positive rates remain high, and human operators often miss infections of more than one species of malaria when one species of parasite dominates. The development of other very useful tools for diagnosis, such as antigen detection using dipstick or ELISA, can provide useful and important information about the presence of parasites, but often fail to accurately speciate or quantify the number of parasites present, and can give false negative results when parasite counts are low (below 100/ul blood). Flow cytometric methods quantify parasites well but fail to speciate, PCR methods speciate well but quanitate poorly, and both involve extensive investments of time, training and technology per sample.
The transition of any antimalarial product through the phases of licensure will require the ability to accurately speciate and quantitate parasite density in a reproducible and scaleable way (3). This may involve development of highly advanced image recognition algorithms to detect parasites in blood films, sample handling or slide handling robots, and the ability to recall either images or slide coordinates for subsequent review and confirmation by human operators. The development, licensure, full clinical certification and rapid, widespread acceptance of automated analysis of the Pap smear for the diagnosis of cervical cancer in women (4,5) is one example of recent advancements in high-throughput robotized smear preparation and slide handling, software, and hardware. Advances like these should be translatable to the accurate reading of malaria films, and significantly improve upon the throughput of early algorithm development efforts (6).

Characteristics required:
Primary: The goal of the project is partial or complete automation of a malaria diagnostic platform with the ability to differentiate between malaria species and quantitate parasite density in an accurate, high-throughput, reproducible, and scaleable way.
Secondary: The project can be staged, with ring recognition for P. falciparum detection the highest priority for Phase I. Ultimately, the system should be flexible and rapid enough to permit detection of additional species and stages (such as older trophozoites, gametocytes, and schizonts) without undue loss of throughput. Either image files, immutable slide coordinates or other permanent record can be saved for subsequent evaluation by human operators, if desired, either for additional review and validation or for regulatory requirements. The number of red cells, or the volume of blood, to be examined should be able to be set by the operator, depending upon the level of accuracy required for the particular situation. Thus, if using thin films, for example, the computer should be able to determine where the boundaries of readability are on a conventionally prepared smear and count or calculate the total number of cells evaluated. Finally, this technology should be developed with the ultimate aim of being ready for GLP validation or CAP/CLIA (or equivalent) certification.
Tertiary (desirable but optional characteristics): The ability to read conventionally prepared, archived slides is desirable and would greatly enhance validation efforts as well as immediately support recent and current clinical and

field trials. Use of conventional techniques for blood film preparation would allow for the most rapid transition to the field, but alternate methods for sample or smear preparation, fixation and staining may be part of the automation package if desired. An ideal system would be fully automated to allow for the continuous analysis of samples with only infrequent attention from an operator. The ability to perform operator verification at a separate workstation, to avoid interruption of sample analysis, would be desirable. The ability of the system to simultaneously provide information about the CBC such as the differential counts and/or the presence of abnormal host cells would be viewed with interest, but is not necessary for the proposal.

PHASE I: Selected contractor determines the feasibility of the concept by developing a prototype algorithm designed only to recognize ring stages of malaria, the most important stage for the detection and quantification of falciparum malaria. A first-generation prototype system (software, hardware and detection system such as microscopy) should be developed and operational by the end of Phase I to demonstrate feasibility. Phase I should also include estimates of ultimate throughput speed. Plans for the development of ancillary automation of sample or smear preparation to enhance either sensitivity, accuracy or speed, if needed, should be developed. Factors to be used in determining award of Phase II contracts will include the ability of the system or proposed system to: 1) accurately diagnose malaria, with high sensitivity and specificity; 2)speciate infections and mixed infections; 3) reproducibly quantify parasite density; 4) allow operator verification of individual parasites, or have other appropriate quality assurance capabilities; and 5) complete the analysis at rates greater than human microscopy. Due to the relative scarcity of malaria parasites in the developed world, the COR will cooperate with successful contractor(s) in arranging for the provision of positive malaria smears at known parasite densities, if necessary and at no cost to the contract, from the Walter Reed Army Institute of Research (WRAIR) or the Naval Medical Research Center (NMRC) and their satellite laboratories in endemic countries.

PHASE II: The primary goal of Phase II is to achieve a platform that will allow for the automated diagnosis and speciation of malaria for research purposes. The selected contractor will continue the process of developing the algorithm, to include the detection of schizonts and gametocytes for P. falciparum, and the ability to detect and accurately speciate the presence of P. malariae and P. vivax/ovale in smears. At the end of Phase II, at least one functional highly automated, high through-put system should be deployable to a research laboratory for use in clinical and field trials.

PHASE III: The selected contractor carries out studies required to obtain FDA approval for the assay system and commercializes the system for the detection of malaria parasites in research settings. Ideally, the contractor also will continue to develop, validate and certify the system for clinical settings. The WRAIR/NMRC may coordinate with the contractor to assist this effort, for example by inclusion of the technology in field trials; however, careful advance coordination by the selected contractor will be required.
At the completion of this project, blood films for the diagnosis and quantification of malaria parasitemia should be read by machine, with operator review for quality control and for the determination of questionable images only.

REFERENCES:

1. Ohrt, C, et al. "Establishing a malaria diagnostics centre of excellence in Kisumu, Kenya" Malaria Journal 2007; 6:79.

2. Dini, L and J Frean "Quality assessment of malaria laboratory diagnosis in South Africa" Trans. Royal Soc. Trop. Med. Hyg. 2003; 97:675-677.

3. Ohrt, C, et al. "Impact of microscopy error on estimates of protective efficacy in malaria-prevention trials" J. Infect. Dis. 2002; 186:540-546.

4. R Lozano, "Comparison of computer-assisted and manual screening of cervical cytology" Gynecologic Oncology 2007;104(1):134-8.

5. Miller et al., "Implementation of the ThinPrep Imaging System in a High-Volume Metropolitan Laboratory" Diagnostic Cytopathology 2007;35(4):213-7.

6. Sio et al. MalariaCount: an image analysis-based program for the accurate determination of parasitemia. J Microbiological Methods, 2007;68(1):11-8.

KEYWORDS: Malaria, diagnosis, parasitemia, automation, Plasmodium, falciparum, vivax, malariae, ovale

A08-T037 TITLE: A Real-Time, Portable Non-Invasive Monitoring System of Muscle Oxygen and pH in Trauma Patients

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a non-invasive, portable monitoring system for real-time measurement of the partial pressure of oxygen (PmO2), oxygen saturation (SmO2) and pH (pHm) in peripheral muscle tissue for the purpose of tracking the reduction in central blood volume that is associated with hemorrhage.

DESCRIPTION: Hemorrhage is a major cause of soldier death. To help soldiers survive major injury, seriously injured soldiers must be quickly identified and appropriate resuscitation techniques applied. Significant loss of blood leads to shock which results in inadequate organ perfusion and tissue oxygenation. The goal of resuscitation from shock is to correct the mismatch between available oxygen and the demands of critical organs. Quick response to hemorrhage, within the first hour, can prevent cardiovascular collapse and death. Traditionally, clinicians have used blood pressure, heart rate, urine output, and systemic measures of oxygen transport such as oxygen delivery and consumption, lactate, arterial pH and base excess to ascertain the severity of shock and response to resuscitation. However, these endpoints are often inadequate markers of successful resuscitation. Recently, we have demonstrated that the partial pressure of oxygen (PmO2) and oxygen saturation (SmO2) in peripheral muscle tissue are altered in proportion with the magnitude of reduction in central blood volume independent of hemodynamic compensatory responses. Therefore, development of a non-invasive sensor capable of providing real-time measures of PmO2 and SmO2 in peripheral muscle tissue could prove significant in the early identification of soldiers most at risk of developing hemorrhagic shock. Inability to rapidly reverse a reduction in muscle oxygen leads to a decrease in muscle pH. Resuscitation to restore normal muscle oxygen without restoring normal levels of pHm leads to poor outcome. The ability to continually monitor both muscle oxygen and pH during resuscitation is expected to significantly improve outcomes by directing the nature of the resuscitation therapy.

PHASE I: In Phase I, miniaturized sensor components should be developed and demonstrated to be equivalent in spectral performance to the larger instrumentation which has previously been demonstrated. New, miniature light sources should be bright enough to acquire spectra with adequate signal-to-noise ratio with very short integration times when coupled with a small spectrometer. Spectra acquired with the new sensor from 3-layer (skin, fat, muscle) phantoms should be equivalent to spectra acquired with the existing CW-NIRS monitor. A design for a miniaturized, hand-held monitor should be completed. PmO2 and pH calculated with spectra from the new sensor should be shown to be equivalent to the existing sensor during arterial occlusion on healthy subjects.

PHASE II: In Phase II a complete system should be developed and tested. The spectroscopic monitoring hardware should be miniaturized to result in a handheld device. User interface software should be written to allow the medic to easily operate the device with a minimal amount of training. The completed device will be evaluated in the Human Physiology Laboratory at the Institute of Surgical Research. This laboratory has developed a human model of early hemorrhagic shock through the use of Lower Body Negative Pressure (LBNP). The new, miniaturized monitor and sensor should be shown to provide an early and repeatable indicator of early, central hypovolemia on subjects with both light and dark skin. After successful validation in the LBNP model the completed device should be ready for clinical testing on trauma patients.

PHASE III: This technology will have immediate battlefield application, and civilian pre-hospital application to be used by paramedics in the field or on ambulances to guide treatment of trauma and shock secondary to blood loss. It will also be applicable in emergency departments, particularly in rural and community hospital settings where sophisticated patient monitoring is not typically available.

REFERENCES:
1. Walz, JM, Convertino, VA., Ryan, K.L. et. al. Intramuscular PO2 determined by near infrared spectroscopy is an early indicator of hemodynamic instability in a lower body negative pressure model of hemorrhagic shock. Shock 26(Suppl 1), 16. 2006.

2. Soller BR, Heard SO, Cingo N, et. al. Application of fiberoptic sensors for the study of hepatic dysoxia in swine hemorrhagic shock. Crit Care Med 29: 1438-1444, 2001.

3. Soller BR, Idwasi PO, Balaguer J, et. al. Noninvasive, NIRS-measured muscle pH and PO2 indicate tissue perfusion for cardiac surgical patients on cardiopulmonary bypass. Crit Care Med 31: 2324-2331, 2003.

4. Yang Y, Landry MR, Soyemi OO et. al. Simultaneous correction of skin color and fat thickness for tissue spectroscopy using a two-distance fiber optic probe and orthogonalization technique. Opt Lett 30: 2269-2271, 2005.

KEYWORDS: Shock, trauma, hemorrhage, blood loss, oxygen, pH, non-invasive, portable monitor.

A08-T038 TITLE: <u>Surgical Tools for the Removal of Solid Tumors with Enhanced Accuracy at the Tumor Margin</u>

TECHNOLOGY AREAS: Biomedical

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

OBJECTIVE: The intent of this research topic is to solicit the development of novel tools, instrumentation or devices that would greatly improve the precision of removing diseased tissues. This solicitation particularly focuses on the accurate removal of tumors while sparing native structures. This is a particular problem in prostate cancer where surgical interventions produce side effects such as urinary dysfunction and impotence . Robotic surgery is a recent breakthrough , however the technology is still rapidly emerging. Advances in the visualization, identification and magnification of tumor margins are also needed. Many of these technologies are benefiting from multidisciplinary advances in materials science and biophysics, but require further study and clinical validation.

DESCRIPTION: In many cancers, pinpoint accuracy is required to remove the entire tumor while sparing benign tissues. Proposals that would seek to develop advanced devices or hardware for 1) improving real-time visualization, identification and magnification of tumor margins and/or 2) enhanced precision of removal by automated means. Examples of research areas of interest include, but are not limited to, advances in robotics, laser-based tools, functional/real-time imaging.

PHASE I: Feasibility: The goal of this phase is to explore the feasibility of the proposed research towards enhancing surgical accuracy for tumor removal. Proposals should clearly outline the principles and history preceding the proposed project, and address how the surgery is performed without this proposed innovation. Strategies regarding the implantation of the technology in the surgical theater should be detailed. If applicable, describe the military relevance to the treatment of brain injuries and shock trauma. Use of human cells and tissues and/or animals requires approval by the appropriate US Army Medical Research and Materiel Command regulatory office. Phase I should include approval of appropriate regulatory documents necessary to execute Phase II.

PHASE II: Prototype Development: Based on the outcomes of Phase I, prototype development will commence with the aim of demonstrating the device, tool or system using in vivo animal models. Preliminary clinical testing in human tissue samples may also be conducted. Experimental plans including the appropriate positive and negative controls should be outlined clearly. The offeror should demonstrate the benefits the research will extend to warfighters and their family members by decreasing deaths due to solid tumors. The platform should decrease the need for secondary surgeries, and recurrences of cancers (i.e. breast cancer). Proposals are encouraged to demonstrate the universality of the platform to show a wide range of use in military and civilian medical applications.

PHASE III: Advanced Development: This phase would involve optimization and clinical testing of the device, tool or system to demonstrate FDA marketability. The candidate product should also demonstrate its capability as a tool for state-of-the-art care of military personnel and DoD beneficiaries. The commerciality potential of a Phase III project is expected to be high. Surgical tools, devices and systems that demonstrate effectiveness in assisting surgeons during tumor removal will have widespread application for the treatment and future mortality and morbidity of cancer patients with solid tumors in both military and civilian sectors. Real-time information and feedback, as well as advances in visual detection in the operating room, will allow surgeons to maximize the extent and accuracy of tumor resection while minimizing the propensity for recurrence. Additional benefits may include improving the diagnostic accuracy of intraoperative biopsies and reducing the cost and discomfort of surgical cancer treatments for solid tumors.

REFERENCES:
1. “Sexual function after surgery for prostate or bladder cancer” Miranda-Sousa AJ, Davila HH, Lockhart JL, Ordorica RC, Carrion RE; Cancer Control. 2006 Jul;13(3):179-87.

2. “Role of robotics in laparoscopic urologic surgery” Eichel L, Ahlering TE, Clayman RV; Urol Clin North Am. 2004 Nov;31(4):781-92.

3. “In Vivo brain tumor demarcation using optical spectroscopy” Lin, Wei-Chiang, Toms, Steven A, Johnson, Mahlon, Jansen, E Duco, Mahadevan-Jansen, Anita Photochemistry and Photobiology, Apr 2001.

KEYWORDS: Surgery, tumor margins, ablation, prostate, ovarian, breast, solid tumor, surgical tools

A08-T039 TITLE: A Real-Time, Non-Invasive Monitoring System of Combat Casualties

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop algorithms for the real-time processing of vital sign signals (Electrocardiogram (ECG), photoplethysmogram (PPG), oxygen saturation (SpO2), Respiratory, and Blood Pressure (BP) for the purpose of tracking physiological compensations due to hemorrhaging in humans. The algorithm will run in real time on a resource constrained portable devices.

DESCRIPTION: Emergency medical treatment is imperative when time and distance limit quick casualty evacuation. The “golden hour,” the first 60 minutes following a traumatic injury, has long been recognized by medical personnel as vital to saving lives. Since hemorrhagic shock remains a leading cause of death on the battlefield (1), it is critical to provide real time monitoring of soldiers with traumatic injuries to medics. The determination of the severity of a soldier’s injury is required in order to establish triage categories, evacuation priority, and required interventions. In trauma patients, arterial pressure, heart rate, arterial oxygen saturation and mentation are monitored periodically during transport: when abnormal they clearly are related to mortality and prompt rapid evacuation and immediate interventions. However, these changes are relatively late secondary markers (decompensated physiologic responses), rather than primary manifestations of hemorrhagic shock, and as such may not provide the first responder with adequate information regarding triage categories, evacuation priority and required interventions (2). Of primary importance is the ability to estimate reductions of central blood volume easily and non-invasively from measured physiological signals, but arterial pressure, heart rate, arterial oxygen saturation, and mentation do not change as a function of blood loss: by the time they do change, the patient is well on their way toward hemorrhagic shock (3,4). While heart rate variability (HRV) is being used extensively to diagnosis a wide variety of conditions (5), there is growing research to indicate that HRV alone is insufficient to accurately assess the condition of the trauma patients. There is emerging evidence that complex relationships between the heart rate, blood pressure and respiratory changes can provide insight into the real-time variations of the central blood volume. In addition, changes in heart rate variability and the sensitivity of the arterial baroreflex (the ability of the heart to respond rapidly to changes in arterial pressure) also seem to change predictably as central blood volume is decreased. Monitoring of pulse pressure, heart rate variability, and/or baroreflex sensitivity in bleeding patients may provide the first responder with an earlier indicator of injury severity than current measures, and therefore may assist the first responder with triage decisions and patient status and prognosis.

PHASE I: Demonstration of proof-of-concept that algorithms to analyze vital signs for tracking physiological compensations due to hemorrhaging in humans and to determine the injury severity of the patient. Contractors should explore novel approaches for the analysis of physiological signals which can lead to the development an effective plan for real-time implementation. In Phase I, the algorithm will process (in near real time) the various physiological signals (such as those collected with a Portapres®). The algorithm will process each of the individual physiological signals and extract the necessary parameters to robustly determine the injury severity of the patient. The successful algorithm will be required to process noisy physiological signals while still maintaining robust performance in tracking the physiological compensations due to hemorrhaging.

PHASE II: The contractor will further develop and optimize the injury severity detection algorithm across various data sets. Optimization of the algorithms will utilize both simulated and actual trauma patient data. In addition, the contractor will implement the injury severity detection algorithm in a real-time portable device. The device will also provide the capability to archive the data along with the results. The device will be tested with both actual and simulated data sets. Evaluations of the system will encompass: data quality, real-time operation, performance measures (e.g. probability of detection and false alarm rate), robustness, and consistency.

PHASE III: A device capable of providing near real-time estimates of hemorrhage severity would assist combat and civilian medics in triage prioritization and intervention decision early in the progression of injury. An added benefit of this approach is that information could theoretically be generated from a remote location before a medic even reaches a casualty. Such a device could save lives by providing critical information on injury severity, and should be of great commercial interest for all branches of the U.S. armed services as well as trauma units around the world.

REFERENCES:
1. Bellamy R F. The causes of death in conventional land warfare: implications for combat casualty care research. Mil Med 1984; 149:55-62.

2. Victor A. Convertino, Col. John B. Holcomb, “Advanced Diagnostics for the Combat Medic,” Army Medical Department Journal, PB 8-03-7/8/9:42-48, 2003.

3. W.H. Cooke, V. A. Convertino, “Heart rate variability and spontaneous baroreflex sequences: implications for autonomic monitoring during hemorrhage,” J Trauma, Apr 2005, 58(4):798-805.

4. Orlinsky M, Shoemaker W, Reis E D, Kerstein M D. Current controversies in shock and resuscitation. Surg Clin North Am 2001; 81:1217-1262.

5. Heart Rate Variability, European Heart Journal, 17, 354-381, 1996.

KEYWORDS: Remote triage, real-time analysis, physiological signals, hemorrhage severity, autonomic nervous system, heart rate variability.

A08-T040 TITLE: Improved Compliance with Antimalarial Prophylaxis Through Novel Routes of Administration

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: The objective is to develop a depot formulation of antimalarial drugs that will provide efficacy with infrequent dosing (minimum of monthly dosing).

DESCRIPTION: Currently highly efficacious malaria prophylaxis drugs and other prevention methods (impregnated bed nets & uniforms) exist. Poor compliance with the methods has led to poor effectiveness and outcomes in the US military. A 2002 experience in Liberia exemplifies the problem. Of 290 troops who stepped ashore, 80 developed malaria (28%), and 69 of the 147 who spent at least one night ashore acquired it (44%). Five of these marines required intensive care unit support. We are fortunate no lives were lost. Incomplete compliance with malaria prevention medication was determined to the cause of the problem. Furthermore, a recent survey of troops returning from Afghanistan reveals fewer than 50% of troop took doxycycline prophylaxis as recommended. Compliance at this low level will have disastrous consequences if major deployments occur in highly malaria-endemic areas.

A depot formulation of a drug would allow for directly observed dosing and prolonged efficacy. Currently, several antimalarials are available that have good efficacy, such as mefloquine, tafenoquine, doxycycline, atovaquone-proguanil, and primaquine. Others are in development at the Walter Reed Institute of Research. A potential limitation of this approach will be the ability to administer enough drug for prolonged (e.g. one month) of efficacy. For all of the drugs listed, this will likely be one gram or more.

PHASE I: Identify appropriate existing technology to modify or develop plan to develop technology in Phase II. Perform initial assessment of modified existing technology if available. The following must be presented at the end of Phase I: feasibility assessment of a method to provide a month's dose of at least one antimalarial drug, ideally with pharmacokinetics or efficacy data in an animal model.

PHASE II: Must develop specific formulation to be used by the US military. It should be compatible and inexpensive for civilian use. Must develop method to remove the drug if toxicity is identified. Must have prototype demonstration. Publish results.

PHASE III: Specifc formulation, human testing and FDA approval. Drug formulation must be FDA approved and become available for purchase by US military for use by military units deploying into malaria-endemic areas. Must maintain methods for iterative improvement of any limitations identified. Must modify technology to suit other military and civilian applications. An efficacious drug formulation technology that will allow depot administration for a month will have great potential for dual use with any drug needing high compliance for public health impact. The formulation developed may assist with malaria elimination worldwide. Publish results.

REFERENCES:
1. Bhanji, N. H., G. Chouinard, et al. (2004). "A review of compliance, depot intramuscular antipsychotics and the new long-acting injectable atypical antipsychotic risperidone in schizophrenia." Eur Neuropsychopharmacol 14(2): 87-92.

2. De Graeve, D., A. Smet, et al. (2005). "Long-acting risperidone compared with oral olanzapine and haloperidol depot in schizophrenia: a Belgian cost-effectiveness analysis." Pharmacoeconomics 23 Suppl 1: 35-47.

3. Kranzler, H. R., D. R. Wesson, et al. (2004). "Naltrexone depot for treatment of alcohol dependence: a multicenter, randomized, placebo-controlled clinical trial." Alcohol Clin Exp Res 28(7): 1051-9.

4. Tzeng, J. I., C. C. Chu, et al. (2005). "The antinociceptive and anti-inflammatory effects of a long-acting depot formulated ketorolac in rats." Acta Anaesthesiol Taiwan 43(1): 17-22.

KEYWORDS: Depot, implant, intramuscular, drug, drug delivery, compliance, adherence, antimalarial, drug development, prevention, military, soldier, malaria, Liberia, special operations

A08-T041 TITLE: Novel Biomarkers Assessment in the Progression from Androgen Dependent Prostate Cancer to Androgen Independent Prostate Cancer

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Most prostate cancers are androgen dependent meaning that they respond to androgen ablation therapy. The mechanisms by which a prostate cancer cell survives after androgen ablation therapy are unknown. Identification of specific biomarkers involved in the androgen independent phenotype will enable investigators to more rationally choose appropriate targets for therapy.

DESCRIPTION: The incidence of prostate cancer has increased modestly during the last 12 years (1) and it is the most frequently diagnosed cancer in men (1). This increase largely reflects the increasing use of screening based on the use of prostate-specific antigen (PSA) testing in the serum. Although PSA is currently the most important biomarker used by the physicians for the diagnosis of prostate cancer and its recurrence, and has shown sensitivity, it suffers from limited specificity (2). Widespread use of PSA has led to over-diagnosis and over-treatment resulting sometimes in unnecessary physical and emotional burden for the patient. Early prostate cancer often does not cause symptoms or, if symptoms emerge, it is very difficult to detect them reliably. The key factor in the early growth of prostate cancer is the involvement of male hormone androgens. Progression from androgen dependent cancer to a more fatal androgen independent prostate cancer is a multi-step process involving androgen receptor (AR) and its associated growth regulatory signal transduction pathways (3). Prostate cancer progression seems to be a complex non-linear biological process and heterogeneous in nature. The majority of prostate cancers (91%) are slow growing tumors affecting men over the age of 60 and are localized, compared with 5% that are staged as "distant" or "metastatic" and 4% unreported. The localized cancers are treated effectively with androgen ablation therapy, surgery, or radiotherapy and sometimes combinations of these. Approximately 20-30% of patients show metastatic disease during initial presentation, and treatment for these patients with androgen ablation therapy after radical prostatectomy (RP) eventually leads to relapse and development of an androgen independent tumor. These patients with androgen independent prostate cancer carry high morbidity and morality. At present the treatment for these particular patients is inadequate and there is a desperate search for alternative therapeutic strategies. Prostate cancer cells have a propensity to spread to bone via dissemination through blood and bone marrow. The characteristics of these circulating tumor cells (CTCs) are not clearly understood but they are currently under intense investigative scrutiny for their potential as surrogate biomarkers (4). There exists an urgent need for novel approaches to identify and validate CTC biomarkers or a panel of biomarkers that are sensitivie and specific and that will identify CTCs at various stages of disease progression and dissemination. These biomarkers can then be used for better diagnosis, prognosis and treatment decisions. Recent advances in the technologies and study of genomics and proteomics, high throughput techniques, and array-based methodologies have led to the discovery of many potential biomarkers for prostate cancer which show differences in the alteration of proteomes between localized and metastatic prostate cancer (5).

The goal of this solicitation is to develop new biomarker candidates for CTCs using the knowledge of novel signal transduction AR-based molecular targets involved in prostate cancer at various stages of disease progression such as androgen dependent to androgen independent state or from localized to metastatic disease. Applying new technologies as referenced above may be useful in this endeavor. It is anticipated that genetic and proteomic profiles of CTCs may differ from metatstatic prostate cancer tissue samples due to the fact that CTCs are separated from their tissue microenvironment. Development of new CTC biomarkers could be beneficial in detecting recurrent disease or hormone resistant disease earlier than is possible with PSA, as well as in serving as surrogate markers of response to chemotherapy.

PHASE I: Validate current methodologies available for the isolation and separation of sufficient quantities of CTCs for either genomic or proteomic analysis from frozen banked and well annotated blood samples. These samples must be de-identified and be exempt from IRB review. Identify new biomarker candidates or a panel of biomarkers targeted toward various stages of prostate cancer progression and development in CTCs. The methodology to identify in vivo molecular entities for any biological measurement made on prostate cancer patients, and the rationale for these molecular entities such as proteins, peptides, genes, antibodies, micro-RNAs etc, should be elaborated.

PHASE II: Determine feasibility of starting in vitro culture systems with this cell population. Initiate evaluation of several molecular entity/biomarker candidates or a panel of them in biological assays and preclinical animal models using developed in vitro cultures of CTCs. Possible uses of biomarkers can be to identify molecular targets for therapy or surrogate end points for phase I/II and phase III clinical trials.

PHASE III: Perform additional experiments with the lead biomarkers candidates and/or a panel to prepare for FDA review, and approval, and subsequent commercialization. Possible uses of biomarkers can be to identify molecular targets for therapy or surrogate endpoints for phase I/II and Phase III clinical trials. They may be used for pre-treatment prediction of response to a specific therapy and selection of appropriate patient population. The biomarkers identified and the technologies developed should yield many advances important not only to the civilian but also to the military community especially to more vulnerable populations such as aged veterans and retired military personnel. Identifying and developing rapid non-surgical tests using these biomarkers will eliminate unnecessary biopsies, minimize over-treatment with radical prostatectomy and radiation, and will have an enormous impact on the quality of life of individuals who have honorably served their country.

REFERENCES:
1. American Cancer Society, Cancer Facts and Figures, 2007.

2. Chatterjee S.K., Zetter, B.R. 2005. Cancer Biomarkers: Knowing the Present and Predicting the Future. Future Oncology 1 (1): 37-50.

3. Dehm S.M., Tindall, 2006 D.J. Molecular Regulation of Androgen Actions in Prostate Cancer. Journal of Cellular Biochemistry 99: 333-344.

4. Morgan T.M., Lange, P.H., Vessella R.L. 2007. Detection and characterization of circulating and disseminated prostate cancer cells. Frontiers in Biosciences 12; 3000-3009.

5. Taylor B.S., Varambally, S., Chinnaiyan, A.M. 2006. Differential Proteomic Alterations between Localized and Metastatic Prostate Cancer. British Journal of Cancer 95: 425-430.

KEYWORDS: Prostate cancer, circulating tumor cell biomarkers, androgen dependence, androgen independent prostate cancer.

A08-T042 TITLE: Advanced Vehicle/Terrain Interaction Modeling to Support Power and Energy Analysis

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop a universal, physics-based, mathematical model of both a tire and a track that can handle a variety of soil, tire and track conditions. The model should take into account the relative stiffness of the tire or track and the soil and calculate the appropriate deformations of both. In addition, the model needs to capture the associated energy losses from the deformations and transfer those losses appropriately back to the vehicle dynamics. This model will provide more accurate lateral, longitudinal and vertical forces acting on the tires or tracks which will result in better energy dissipation analysis. The total effect will be more accurate vehicle power and energy predictions.

DESCRIPTION: For on-road vehicles at speeds lower than thirty miles per hour rolling resistance is the primary source of drag and therefore has the primary impact on fuel economy. For off-road vehicles after braking and power train losses, soil deformations, tire deformations, loss of traction as well as shock activity are the primary energy absorbers across the full range of vehicle speeds. Multi-body dynamics models of the vehicle coupled with accurate shock models have been implemented as part of the High Fidelity Ground Platform and Terrain Mechanics Army Technology Objective (ATO). These models can currently accurately predict shock energy absorption given accurate tire loads and forces. However accurate tire and soil deformations and their associated energy losses have not been effectively captured across the complete performance envelope.

While TARDEC has conducted some preliminary research into vehicle/terrain interaction (VTI) modeling, the current state-of-the-art in VTI modeling in real-time needs much improvement. This modeling effort will provide the government and industry a real-time modeling methodology that will accurately capture forces imparted to both the tire/track and terrain along with deformations to both, something that does not currently exist.

There are a range of tire, track and soil conditions that must be considered. Soil can be soft, firm, or can be hard pavement. In addition tires can be run at a variety of inflation pressures. Finally track elements are typically very stiff and show very little deformation with respect to the ground. This leads to several possible combinations of conditions:

- Track on soft soil
- Track on firm soil
- Track on paved roads
- Soft tire on soft soil
- Soft tire on firm soil
- Soft tire on paved roads
- Firm tire on soft soil
- Firm tire on firm soil

- Firm tire on paved roads

In current vehicle dynamics modeling each of the above conditions is represented with an independent model. Firm and soft tires on paved roads typically use simple non-linear relationships for tire deflection with additional empirical rolling resistance calculations. The High Fidelity Ground Platform and Terrain Mechanics ATO developed models of firm tires on soft and firm soil. This model assumes that the majority of deformation occurs in the soil. Track models typically assume no deformation of the track or the shoes and assume complete deformation of the soil. This leads to no solution for paved roads where neither the track nor the roads can be assumed to deform to a large degree.

In the case of evaluating power and energy demands across mixed terrain courses, a single tire or track model cannot be used since the terrain conditions can move from soft soil, to firm soil, to paved roads. In additional, central tire inflation allows operators to rapidly adjust their tire pressures as required.

Therefore it is important, if possible, to develop a universal model that can handle a variety of soil, tire and track conditions. The model should take into account the relative stiffness of the tire or track and the soil and calculate the appropriate deformations of both. In addition the model needs to capture the associated energy losses from the deformations and transfer those losses appropriately back to the vehicle dynamics. This model will provide more accurate vertical forces acting on the tires which will result in better shock absorber energy analysis. The total effect will be more accurate vehicle power and energy predictions.

Beyond power and energy calculations, the improvement in tire force analysis can be used to more accurately determine ride safety from rollovers, mobility and comfort.

PHASE I: Identify current models and software technologies that will be used to feed a highly accurate vehicle/terrain interaction to be developed under this research project. Develop an outline of steps needed to accomplish the tasks under Phase II. Research work done in the area Vehicle Terrain Interaction and identify how the research performed under this topic will enhance current methods.

PHASE II: Fully develop a track, firm tire and soft tire model using physics based mathematical equations. This model shall be integrated into a (Government Furnished Equipment) GFE vehicle model developed in SimCreator and able to execute in real-time. The model's output shall be compared to (Government Furnished Information) GFI test data to determine accuracy. The track/tire model shall conform to GFI input/output parameters to allow plug-and-play between vehicle models and terrain inputs.

Perform verification and validation (V&V) of the developed model to a reasonable extent. The government will provide as GFI data collected from previous tests involving tire/terrain interactions. It is also strongly recommended that the research team perform their own data collection for V&V or contract the government or another agency (since instrumentation costs make procurement infeasible for this effort) to collect data.

PHASE III/DUAL USE APPLICATIONS: The development of a tire/track model can immediately benefit the military in a few ways. It can be incorporated, since it runs in real-time, to Semi-Automated Force (SAF) programs such as OneSAF to improve the realism and accuracy of force-on-force scenarios. It will also be used in support of ground vehicle procurement programs to increase the fidelity of the modeling and simulation efforts focusing on mobility and maneuverability. On the commercial side, this technology will also apply to farming and construction heavy equipment, looking at the vehicle/terrain interactions in both on-road and off-road conditions.

REFERENCES:
1. Paul W. Richmond, Burhman Q. Gates, Erwin A. Baylot, Modeling Vehicle-Terrain Interaction in Army Simulations, 2005 SAE Commercial Vehicle Engineering Conference, Nov. 2005.

2. Alexander A. Reid, Sally Shoop, Randy Jones, Patrick Nunez, High-Fidelity Ground Platform and Terrain Mechanics Modeling for Military Applications Involving Vehicle Dynamics and Mobility Analysis, Proceedings of the Joint North America, Asia-Pacific ISTVS Conference and Annual Meeting of Japanese Society for Terramechanics, Fairbanks, AK, June 2007.

KEYWORDS: Tire, track, vehicle/terrain interface, deformation, physics-based modeling, simulation.