DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY2009.3 SBIR Proposal Submission

DARPA's mission is to prevent technological surprise for the United States and to create technological surprise for its adversaries. The DARPA SBIR and STTR Programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.

The responsibility for implementing DARPA's Small Business Innovation Research (SBIR) Program rests with the Innovative Research Office.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Attention: DIRO/SBIR/STTR
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Arlington, VA 22203-1714
(703) 526-4170
Home Page http://www.darpa.mil

Offerors responding to the DARPA topics listed in Section 8.0 of this solicitation must follow all the instructions provided in the DoD Solicitation Instructions preface. Specific DARPA requirements in addition to or that deviate from the DoD Solicitation Instructions are provided below and reference the appropriate section of the DoD Solicitation Instructions. All proposals must be submitted electronically through the DoD SBIR Web site at http://www.dodsbir.net/submission by the submission deadline. Proposals provided in hard copy or via e-mail will not be accepted. In addition, all topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be accepted.

SPECIFIC DARPA REQUIREMENTS:

2.15 Foreign National

DARPA topics are unclassified; however, the subject matter may be considered to be a "critical technology" and may be subject to ITAR restrictions. If you plan to employ NON-U.S. Citizens in the performance of a DARPA SBIR contract, please inform the Contracting Officer who is negotiating your contract. See **Export Control** requirements below in Section 5.

3.7 Phase II Proposal Format

DARPA Program Managers may invite Phase I performers to submit a Phase II proposal based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3 of the SBIR 9.B3 solicitation. Phase II proposals will be evaluated in accordance with the evaluation criteria provided in Section 4.3. Due to limited funding, DARPA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

4.0 Method of Selection and Evaluation Criteria

The offeror's attention is directed to the fact that non-Government advisors to the Government may review and provide support in proposal evaluations during source selection. Non-government advisors may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. These advisors will not establish final assessments of risk and will not rate or rank offeror's proposals. They are also expressly prohibited from competing for DARPA SBIR or STTR awards in the SBIR/STTR topics they review and/or provide comments on to the Government. All advisors are required to comply with procurement integrity laws and are required to sign Non-Disclosure and Rules of Conduct/Conflict of Interest statements. Non-Government technical consultants/experts will not have access to proposals that are labeled by their proposers as "Government Only."

4.2 Evaluation Criteria

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives twice the weight to Criterion A. "The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution." Please note proposals that scored low on evaluation Criterion C. "The potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization" are considered weaker proposals. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposals is deemed superior and are highly relevant to the DARPA mission, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

4.4 Assessing Commercial Potential of Proposals

DARPA is particularly interested in the potential transition of SBIR project results to the U.S. military, and expects explicit discussion of a transition vision in the commercialization strategy part of the proposal. That vision should include identification of the problem, need, or requirement in the Department of Defense that the SBIR project results would address; a description of how wide-spread and significant the problem, need, or requirement is; identification of the potential end-users (Army, Navy, Air Force, SOCOM, etc.) who would likely use the technology; and the operational environments and potential application area(s).

Technology commercialization and transition from Research and Development activities to fielded systems within the DoD is challenging. Phase I is the time to plan for and begin transition specific activities. The small business must convey an understanding of the transition path or paths to be established during the Phase I and II projects. That plan should include the Technology Readiness Level (TRL) at the start and end of the Phase II. The plan should also include a description of targeted operational environments and priority application areas for initial Phase III transition; potential Phase III transition funding sources; anticipated business model and identified commercial and federal partners the SBIR company has identified to support transition activities. Also include key proposed milestones anticipated during Phase I, II or beyond Phase II that include, but are not limited to: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.

4.5 SBIR Fast Track

- DARPA encourages Phase I performers to discuss its intention to pursue Fast Track with the DARPA Program Manager prior to submitting a Fast Track application or proposal. Selection of a Fast Track proposal is not mandated and DARPA retains the discretion to not select or fund any Fast Track proposal.
- After coordination with the DARPA Program Manager, the performer and the investor are required to submit a Fast Track application through the DoD Submission Web site no later than the last day of the 6th month of the Phase I effort.
- The Fast Track Interim amount is not to exceed $40,000.

- The performer must submit its Phase II proposal before the last day of the 7th month of the Phase I effort.

4.6 Phase II Enhancement Policy
DARPA will provide a Phase II performer up to $200,000 of additional Phase II SBIR funding if the performer can match the additional SBIR funds with non-SBIR funds from DoD core-mission funds or the private sector. Generally, the additional Phase II funds are applied to the Phase II contract. Phase II Enhancements are subject to the availability of funds.

4.7 Commercialization Pilot Program
DARPA does not participate in the Commercialization Pilot Program (CPP); however, DARPA has established a Transition Support Pilot Program focused on transitioning innovative technologies to the most critical U.S. military end-users as well as key collaboration partners. This program will also support transitions within DARPA, civilian agencies, and private-sector, if deemed critical for technology transition success. The program, administered by the DARPA SBIR Program Office with support from The Foundation for Enterprise Development (The Foundation), a U.S. owned non-profit organization, consists of the following assistance:

- Transition Assistance. The Foundation will provide DARPA funded SBIR Phase II companies identified to participate in the Pilot with guidance and assistance in identifying and facilitating introductions to potential collaborators, funding sources, and end users, in support of SBIR Company’s Phase III technology development activities. Thus, identification of potential funding sources will be primarily focused on enabling the SBIR Company to work towards reaching Technology Readiness Level (TRL) 7 – System prototype demonstration in an operational environment. Specific potential funding sources will be identified throughout a designated period of transition support and may include, but are not limited to:
  - DARPA
  - Other DoD research programs (e.g.: Army, Navy, Air Force, Marine Corps)
  - Prime contractor programs, to include their Independent Research & Development (IR&D) programs
  - Non-DoD Federal research programs in the Intelligence agencies and the Department of Homeland Security
  - Other non-DoD Federal research programs, such as those within National Institutes of Health
  - Other DoD-funded technology transition programs as appropriate (e.g., Technology Transition Initiative, Defense Acquisition Challenge, TechLink and TechMatch)
  - Venture capital funding sources

To be eligible for assistance, the SBIR Company must have an active Phase II, expected technology readiness level of 5 or greater at the completion of Phase II, and understanding of and progress within the expected transition path or paths. DARPA retains the discretion to not select a company. Each identified company will execute a Technology Transition Agreement with the contractor to initiate support. Participation in the DARPA Technology Transition Pilot Program is voluntary.

- All obligations of the SBIR Company shall be carried out at no cost to The Foundation or DARPA and are not billable to any SBIR contract. The SBIR Company shall make relevant experts reasonably available to The Foundation to discuss potential application areas for the technology under development and to support the execution of the technology transition support services described above. The SBIR Company also shall make its relevant experts available for follow-up discussions and briefings with potential collaborators or representatives from federal or other potential funding sources. As appropriate, the SBIR Company will develop appropriate company profiles, briefings and other types of informational materials to support discussions and briefings. SBIR companies involved in the transition pilot will be asked for feedback on the assistance provided upon completion of the Phase II and on transition outcomes within the year following the Phase II.

- Success Reports: The Foundation will document company Phase III transition successes individualized reports as well as or other printed material for distribution at outreach events and for posting on the DARPA SBIR Web site. SBIR companies that have received Phase III funding are eligible to work with The Foundation to develop the success report. Cleared Success Reports will continue to be posted on the DARPA SBIR Web site. The 2007 DARPA SBIR Success Reports can be viewed at this link: http://www.darpa.mil/sbir/Success_Story_Main_Page.htm

- Outreach/Process Improvement: The Foundation will capture lessons learned, program feedback and best practices from SBIR companies, and will help develop and implement process improvements to increase transition success for DARPA SBIR funded companies. Transition outreach includes panel presentation and one-on-one meetings at selective SBIR conferences. Additional transition–related documentation and links will be available upon request and via the SBIR Web site in the future. All active DARPA SBIR companies are eligible for this outreach support.

- Phase III transition support is subject to the availability of funds.

5.1.b. Type of Funding Agreement (Phase I)

- DARPA Phase I awards will be Firm Fixed Price contracts.
- Companies that choose to collaborate with a University must highlight the research that is being performed by the University and verify that the work is FUNDAMENTAL RESEARCH.
- Companies are strongly encouraged to pursue implementing a government acceptable cost accounting system during the Phase I project to avoid delay in receiving a Phase II award. Visit www.dcaa.mil and download the "Information for Contractors" guide for more information.

5.1.c. Average Dollar Value of Awards (Phase I)

DARPA Phase I proposals **shall not exceed $99,000,** and are generally 6 months in duration. Phase I contracts will not be extended.

5.2.b. Type of Funding Agreement (Phase II)

- DARPA Phase II awards will be Cost Plus Fixed Fee contracts.
- DARPA may choose to award a Firm Fixed Price Phase II contract on a case-by-case basis. However, companies are advised to continue pursuit of implementation of a government acceptable cost accounting system in order to facilitate their eligibility for future government contracts.
- Companies that choose to collaborate with a University must highlight the research that is being performed by the University and verify that the work is FUNDAMENTAL RESEARCH.

5.2.c. Average Dollar Value of Awards (Phase II)
DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000.

5.3 Phase I Report
All DARPA Phase I and Phase II awardees are required to submit a final report, which is due within 60 days following completion of the technical period of performance and must be provided to the individuals identified in Exhibit A of the contract. Please contact your contracting officer immediately if your final report may be delayed.

5.11.r. Export Control
The following will apply to all projects with military or dual-use applications that develop beyond fundamental research (basic and applied research ordinarily published and shared broadly within the scientific community):

(1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

(2) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at any Government installation (whether in or outside the United States), where the foreign person will have access to export-controlled technologies, including technical data or software.

(3) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(4) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

Please visit http://www.pmddtc.state.gov/regulations_laws/itar.html for more detailed information regarding ITAR requirements.

5.11.s. Publication Approval
There shall be no dissemination or publication, except within and between the Contractor and any subcontractors, of information developed under this contract or contained in the reports to be furnished pursuant to this contract without prior written approval of the DARPA Technical Information Officer (DARPA/TIO). All technical reports will be given proper review by appropriate authority to determine which Distribution Statement is to be applied prior to the initial distribution of these reports by the Contractor. Papers resulting from unclassified contracted fundamental research are exempt from prepublication controls and this review requirement, pursuant to DoD Instruction 5230.27 dated October 6, 1987. Any publications shall incorporate an Acknowledgement of Support and Disclaimer in accordance with FAR 252.235-7010.

The following provision will be incorporated into any resultant contract:

When submitting material for written approval for open publication as described above, the Contractor/Awardee must submit a request for public release to the DARPA TIO ***5 weeks prior to the event.*** Requests received with a due date of less than five weeks lead time require a justification. Unusual electronic file formats may require additional processing time. Include the following information:

1) Document Information: document title, document author, short plain-language description of technology discussed in the material (approx. 30 words), number of pages (or minutes of video) and document type (briefing, report, abstract, article, or paper);

2) Event Information: event type (conference, principle investigator meeting, article or paper), event date, desired date for DARPA's approval;

3) DARPA Sponsor: DARPA Program Manager, DARPA office, and contract number; and

4) Contractor/Awardee Information: POC name, e-mail and phone.

Requests can be sent either via e-mail to tio@darpa.mil or via surface mail to 3701 North Fairfax Drive, Arlington VA 22203-1714, telephone (571) 218-4235. Refer to http://www.darpa.mil/tio for information about DARPA's public release process.

5.14.h. Human and/or Animal Use

This solicitation may contain topics that have been identified by the program manager as research involving Human and/or Animal Use. In accordance with DoD Policy, human and/or animal subjects in research conducted or supported by DARPA shall be protected. Although these protocols will most likely not be needed to carry out the Phase I, significant lead time is required to prepare the documentation and obtain approval in order to avoid delay of the Phase II award. Please visit http://www.darpa.mil/sbir/ to review the Human and Animal Use PowerPoint presentation(s) to understand what is required to comply with human and/or animal protocols.

- **Human Use:** All research involving human subjects, to include use of human biological specimens and human data, selected for funding must comply with the federal regulations for human subject protection. Further, research involving human subjects that is conducted or supported by the DoD must comply with 32 CFR 219, Protection of Human Subjects (http://www.dtic.mil/biosys/downloads/32cfr219.pdf), and DoD Directive 3216.02, Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research (http://www.dtic.mil/whs/directives/corres/pdf/321602p.pdf).

- **Animal Use:** Any Recipient performing research, experimentation, or testing involving the use of animals shall comply with the rules on animal acquisition, transport, care, handling, and use in: (i) 9 CFR parts 1-4, Department of Agriculture rules that implement the Laboratory Animal Welfare Act of 1966, as amended, (7 U.S.C. 2131-2159); (ii) the guidelines described in National Institutes of Health Publication No. 86-23, "Guide for the Care and Use of Laboratory Animals"; (iii) DoD Directive 3216.01, “Use of Laboratory Animals in DoD Program.”

6.3 Notification of Proposal Receipt

DARPA will send each offeror an e-mail acknowledging receipt of proposal after the solicitation closing date.

6.4 Information on Proposal Status
All letters notifying offerors of selection or non-selection will be sent via e-mail to the person listed as the "Corporate Official" on the proposal.

6.5 Debriefing of Unsuccessful Offerors
DARPA will provide each unsuccessful offeror an automatic debriefing summary as an enclosure to the notification of non-selection. Requests for clarification to information provided in the debriefing summary must be sent via e-mail to sbir@darpa.mil within 15 days of receipt of notification.

DARPA SBIR 093 Topic Index

DARPA SBIR 093 Topic Descriptions

SB093-001 TITLE: Multi-Material Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate concepts, for transitioning between two or more dissimilar materials (e.g., composite-to-steel) for marine composite structure applications.

DESCRIPTION: Although composite-to-composite and composite-to-metal joining technologies have been successfully demonstrated and transitioned to the production environment, minimizing corrosion at composite-to-steel interfaces is a constant challenge to the ship design community. Fiber-reinforced plastics are resistant to general corrosion; in fact aramid (used for top-side ship structure fragmentation protection) and glass fiber reinforced composites may be fastened or joined with almost any fastener material to metals without fear of galvanic corrosion. On the other hand, carbon fiber reinforced composites can induce galvanic corrosion in the metal structures, or metal fasteners if the carbon fibers are not galvanically isolated from the metal.

PHASE I: Lightweight, corrosion resistant, structurally robust composite-to-steel joint design concepts shall be developed for potential surface or ground vehicle composite-to-metal applications. Steel surface preparation, galvanic isolation, non-destructive interface integrity inspection, manufacturing and assembly methods shall be proposed for each candidate attachment concept.

PHASE II: A detailed design and manufacturing process for the composite-to-steel joint shall be developed for the Phase I concept. The joint shall be fabricated, non-destructively inspected, subjected to cyclic corrosion (GM9540) and continuous salt-fog testing (B-117) then statically tested to failure to demonstrate the performance capabilities of the system.

PHASE III DUAL USE APPLICATIONS: Insert the product into a candidate marine application and test as part of other technology demonstrator activities. The joint technology developed under this topic could be applied to any sea, land or air vehicle where corrosion resistant, lightweight composite-to-steel joints are required. Potential commercial applications shall be identified and recurring and non-recurring estimates shall be provided for the transition of the Phase II composite-to-steel joint manufacturing (and quality control) process to higher-rate production quantities conducive to the proposed commercial application.

REFERENCES:
1. Heider, D., Deffor, H., Reuter, M., Gillespie, J.W., Jr., "Large-Scale Joint Fabrication Using 3-D Fabric Preforms, Sandwich Core Structure and VARTM Processing", Society for the Advancement of Material and Process Engineering, Vol. 44, No. 5 (2008)

2. Messler, R.W., Jr., "Joining Composite Materials and Structures: Some Thought-Provoking Possibilities" Journal of Thermoplastic Composite Materials, Vol. 17, No. 1, 51-75 (2004)

KEYWORDS: Composite materials, composite structures, joining, structural transitions, manufacturability

SB093-002 TITLE: Handheld Sensor for Amorphous Coating Integrity

TECHNOLOGY AREAS: Materials/Processes

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: Identify and develop sensing techniques that lead to the design and fabrication of a handheld sensor device for the determination of Fe-based amorphous corrosion barrier coating integrity.

DESCRIPTION: Corrosion is a major maintenance issue that costs the US Navy billions of dollars per year in time, manpower and materials. In an effort to mitigate corrosion in the fleet, a new thermally sprayed, Fe-based amorphous coating has been developed (Naval Advanced Amorphous Coatings, or NAAC). This coating is designed to be a life-of-ship, hard, durable and corrosion resistant barrier. The coatings are very robust. The intention of this effort is to develop a sensing technique / sensor to determine the in-service integrity of the NAAC coatings. It is not always obvious that the coating integrity has been compromised during a visual inspection and it is necessary to develop a methodology for determination of coating in-service reliability.

PHASE I: Identify and develop sensing techniques for the determination of Fe-based amorphous corrosion barrier coating integrity without having to remove an in-service part for inspection. Provide a conceptual design for the fabrication of a handheld sensor device. Phase 1 deliverables include a conceptual design for the prototype sensor, and a package of analysis and simulation to confirm that the design meets the goal.

PHASE II: Finalize the design for and fabricate a handheld sensor prototype that effectively determines the integrity of in-service NAAC coatings. Deliverables include: final prototype design; a prototype handheld sensor; a test plan that demonstrates the prototype in an operational environment that meet required performance parameters; experimental data validating the performance of the prototype; a report on required manufacturing capability; and, a report on projected acquisition costs.

The desired Technology Readiness Level (TRL) at the end of Phase II will be TRL6.

PHASE III DUAL USE APPLICATIONS: The technology has the potential for wide use in commercial industrial applications in which amorphous metal coatings have been used to prevent or inhibit corrosion or wear. The technology will have potential to transition to the US Navy for use aboard ships to determine the integrity of in-service Naval Advanced Amorphous Coatings (NAAC) coatings.

There are multiple commercial applications for the technology in oceanographic sensors, industrial flow control, aerospace and biotechnology.

REFERENCES:
1. Farmer, J., Haslam, J., Day, S., Lian, T., Saw, C., Hailey, P., Choi, J.-S., Yang, N., Blue, C., Peter, W., Payer, J., Branagan, D., "Corrosion resistances of iron-based amorphons metals with yttrium and tungsten additions in hot calcium chloride brine and natural seawater: Fe 48Mo14Cr15y2C15B 6 and W-containing variants". ECS Transactions, Vol. 3, No. 31 (2007)

KEYWORDS: Amorphous Coatings, Corrosion Barriers, Sensors

SB093-003 TITLE: <u>Combat Resilience: Inoculating the Warfighter Against Combat Stress</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and demonstrate novel approaches for inoculating Warfighters against psychological stress injuries resulting from exposure to military combat operations.

DESCRIPTION: Stress-related disorders are among the most prevalent and expensive medical consequences of participation in military operations. Current reports suggest that the percentage of subjects meeting screening criteria for major depression, generalized anxiety, or post traumatic stress disorder (PTSD) is about 20 percent after duty in Iraq and more than 10 percent after duty in Afghanistan (1), nearly 3 times the estimated prevalence in the general population (2). Although post-onset treatments for stress-related disorders have shown some success (3), these treatments often require long–term care with significant one-on-one interactions between the Warfighter and clinician. Combined with the personal cost, recent estimates indicate that Warfighter psychological stress injuries could cost the nation up to $6 billion (4). Consequently, successful strategies that protect against combat stress reactivity will provide a critical and timely way to reduce the personal, financial and manpower costs associated with long term, or intense, exposure to military combat operations.

There is currently no intervention that effectively inoculates Warfighters against the complex stressors of combat operations. Most, if not all, existing treatment approaches are targeted post-symptom onset and do not attempt to prevent the changes in neural function that lead to the formation of stress related disorders. A more effective and safe approach would be to develop methods that inoculate military personnel against combat stress reactivity before they are affected with these disorders – either prior to exposure to the aggravating stimuli or shortly following such exposure (i.e. post-exposure but pre-onset). Since there are likely many factors contributing to the neuropsychological changes underlying stress disorders, a multi-modal approach to providing this combat resilience should be most effective. Consequently, potential solutions would combine neuro-pharmacological approaches that either inoculate against the damaging neural effects of stress pre-traumatic exposure (6) or prevent the harmful changes in neural function post-traumatic exposure (7) with cognitive approaches that emphasize resilience-building interventions like controlled stress exposure (5,8).

The results of this effort will be one or more novel intervention(s) that quantifiably reduce the prevalence of combat stress injuries in military personnel. The intervention will be safe, free of short- or long-term health consequences, easily administered prior to, during deployment or immediately following a traumatic event and will significantly reduce stress related disorders across a wide range of operational environments. The intervention will be based on well-defined mechanistic neuroscience principles. Multidisciplinary solutions or solutions that include multimodal approaches are encouraged (e.g. pharmaceutical, bio-behavioral, virtual technology or any combination thereof.).

PHASE I: Prepare a feasibility study on one or more inoculations of stress related disorders for use in the operational setting. The study will include discussion of likely targets for proposed therapy, including mechanisms through which stress related disorders would otherwise develop, and why the proposed approach should work. Study should also include assessment of the proposed mode of action, short and long term effects, and projected costs and benefits. Safety, efficacy and 'per-treatment' cost will be considered critical performance metrics. A final report will be generated, including performance metrics and plans for Phase II. Phase I should also include the processing and submission of all required human subjects use protocols.

PHASE II: Develop a stress inoculation methodology based on the preliminary design from Phase I. Phase II plans should include key development milestones and plans for at least one operational test and evaluation. All appropriate development and testing will be performed including a critical design review to determine the effectiveness and practicality of the exogenous intervention for implementation on a large scale. Phase II deliverables will include: (1.) a model of the proposed intervention and expected effects, (2.) an experimental assessment of the operational test, and (3.) an operational evaluation collected in one or more real world settings.

Target TRL: 6

PHASE III DUAL USE APPLICATIONS: This technology will have broad application in any setting where personnel are exposed to highly stressful events that have a high probability of inducing stress and stress-related disorders. For the military, stress inoculation solutions may be integrated into the combat performance cycle in three stages: 1) pre-deployment training curricula, such as survival, evasion, resistance, and escape (SERE) training; 2) during deployment to combat zones, administered by Combat Operational Stress Control (COSC) units; and, 3) as part of re-acclimation programs at the end of tour. In commercial settings, these solutions may be similarly integrated into existing training programs or as part of the daily preparation cycles. Commercial applications in which these solutions are expected to be particularly effective include: Disaster and Crisis Management, First Responders, Law Enforcement and Humanitarian Relief efforts.

REFERENCES:
1. Hoge C.W., Castro C.A., Messer S.C., et al: (2004). "Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care", New England Journal of Medicine. 351: 13-22.

2. Kessler, R.C, Sonnega, A, Bromet, E, Hughes, M, Nelson, C.B. (1995). "Posttraumatic stress disorder in the National Comorbidity Study", Arch Gen Psychiatry. 52(12): 1048-1060.

3. Mades, D.D., Mello, M.F., Ventura, P, Passarela, C. de M, Mari, J. de J. (2008). "A systematic review on the effectiveness of cognitive behavioral training for posttraumatic stress disorder", Int J Psychiatry Med. 38(3): 241-259.

4. Kennedy, K (2008), "1 in 5 combat vets has PTSD or TBI", Army Times. Retrieved from: www.armytimes.com/news/2008/04/military_ptsd_study_041808w/

5. Taylor, M.K. "Novel interventions to mitigate stress and preserve performance during military survival training". (in preparation).

6. Morgan, C.A III, Southwick S, Hazlett G, Rasmusson, A, Hoyt, G, Zimolo, Z, Charney, D. (2004). "Relationships among plasma dehydroepiandrosterone sulfate and cortisol levels, symptoms of dissociation, and objective performance in humans exposed to acute stress". Arch Gen Psychiatry. 61(8):819-25.

7. McGhee L.L., Maani C.V., Garza T.H., Gaylord K.M., Black I.H. (2008). "The correlation between ketamine and posttraumatic stress disorder in burned service members" J Trauma. 64(2 Suppl):S195-8.

8. Reger G.M., Gahm G.A. "Virtual reality exposure therapy for active duty soldiers". (2008). J Clin Psychol. 64(8):940-6.

KEYWORDS: Stress, inoculation, military, training, mitigation, PTSD, depression, psychological disorder

SB093-004 TITLE: Massively Distributed Problem-Solving (MDPS)

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a problem-solving system that combines an automated optimizing infrastructure with myriad distributed human processing agents.

DESCRIPTION: This topic seeks to leverage an untapped national resource, the millions of educated Internet users in this country, which could be used to solve important, complex problems of national and global interest. Many problems with far-reaching consequences for our country and national security remain unsolved today even though the conceptual knowledge necessary to solve them is latent in our populace. There are several reasons for this, but perhaps the most consequential one is that very large groups of distributed people with common goals do not self-organize effectively due to complex logistical and sociological factors.

Consider, however, an automated system that could direct collaboration among experts within distinct fields of endeavor. Such a system would ensure that problems are attacked from many angles. It would extend the scope of contribution to non-domain experts via sub-problem delegation. Furthermore, it would be suitable for classified initiatives by providing compartmentalization via problem decomposition and by reformulating problems to remove identifiable, domain-specific problem characteristics that aren't relevant to generating a solution.

The growing popularity of online communities (e.g., Facebook, MySpace, Orkut, Habbo, Friendster, etc) and proven successes of distributed computing projects (e.g., Einstein@Home, Rosetta@home, Malaria Control, SIMAP, etc) raises the question of whether or not these two Internet phenomena can be merged into a problem-solving system like the one described above, which would leverage the respective strengths of humans and machines to effectively overcome existing barriers to large-scale human collaboration.

Distributed computing architectures (DCA) may point toward an answer. DCAs permit millions of computers to work together toward a common goal. Collaboration on such a massive scale is made possible by a server computer that organizes the interaction of multiple client computers over the Internet. In its simplest form, the server sends discrete parcels, called "work units", to each client for processing. When processing is complete, the client sends the result back to the server for integration with other incoming results. This approach has led to distributed systems that exceed the performance of today's fastest supercomputers.

The present idea is to extend the notion of a distributed computing architecture to a distributed problem-solving architecture (DPSA) by substituting humans for computers as the processing nodes. In this approach, a server would queue up candidate problems that were submitted by humans, generate work units geared toward prioritizing and solving the queued problems, and distribute those work units to humans for processing (via a thin client). The server would be responsible only for directing collaboration (i.e. task delegation, data-routing, performance optimization, and reporting). All of the higher-order reasoning tasks, such as prioritization, problem reformulation/decomposition/reconstitution, solution evaluation, etc., would fall to humans.

Thus, much of the innovative work to be done here involves characterizing the functionality of the DPSA server software, including the set of problem types that can be farmed out to humans, the set of acceptable responses associated with each problem type, the process rules governing the flow of information, and the nature of the system output. Any approaches that address this central objective are welcome.

PHASE I: Investigate relevant research in distributed computing, problem decomposition, cooperative distributed problem-solving, multiscale decision making, and the psychology of social networking. Design a practical distributed human problem-solving system, giving careful consideration to the human interface and factors that would motivate performance as well as participation on a massive scale. Define clearly the metrics and testing procedures that would be used to evaluate both the usability and problem-solving capability of a prototype system in Phase II.

PHASE II: Develop an online prototype of the distributed human problem-solving system. Demonstrate empirically the problem-solving capability of the system. Show further that it optimizes its use of humans based upon their respective strengths using experiential data. Finally, provide strong evidence that humans will indeed participate at the level necessary to result in the demonstrated problem-solving performance of the system. Please be advised that if human subjects will be used in Phase II, prior Human Subjects Research approval will be required (See Human Subject Research Training Slides, online: www.darpa.mil/sbir). The target Transition Readiness Level (TRL) to be reached at the conclusion of the Phase II effort is TRL3.

PHASE III DUAL USE APPLICATIONS: Complex problems with high stakes exist in both the public and private sectors. Many applications would benefit from systems with demonstrated success in exceeding existing problem-solving capabilities. Organizations could utilize such a system intramurally to leverage more effective use of existing resources, or extramurally by accessing a larger cognitive pool. In all cases, the ability to effectively combine the efforts of very large numbers of experts toward the resolution of complex problems is expected to result in significant capability advancements that previously weren't possible.

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KEYWORDS: Coordinated Distributed Problem Solving, Multiscale Decision-making, Problem Decomposition, Collective Cognition, Global Consciousness, Crowdsourcing, Human Computation, Distributed Thinking.

SB093-005 TITLE: Tactile Detection Robotic Hand System

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Design and build a hand, arm, and processing system to identify objects using only tactile feedback, similar to the skin on a human hand.

DESCRIPTION: Human beings are successful in part due to our ability to reason and utilize tools. A key component of this ability is the flexibility, speed, and sensitivity of our hands to manipulate our environment. Recent trends in robotic development have improved multi-fingered hand technologies, such as the DARPA's "Advanced Prosthetics" program or the "Robonaut" program which both focus on grasping behaviors. However, these programs do not focus on the very sensitive tactile feedback of human skin, including its ability to determine size, weight, thermal characteristics, and texture of an object. To illustrate, imagine reaching into a backpack to grasp an umbrella, which would be identified by touch alone.

Under this program, a prototype robotic hand system, including skin and muscles (actuators), will be developed. This system will be measured by its performance on a "Tactile Object Recognition" task. In this task, the robot hand system will be presented with several objects that vary in their physical characteristics (e.g. a block of wood, a brick, a stuffed animal, and a feather), and asked to select the appropriate object from the set using only its skin and muscles to make the determination.

The robotic skin and muscle system should have similar size, weight, and flexibility characteristics as a human hand and arm system, and include a five finger assembly which fits into a standard large work glove. Skin sensitivity regions should cover as much of the hand as possible. The skin should contain many pressure sensors per centimeter, attempting to attain a human's fingertips which have over 1,000 pressure sensors per centimeter. The fingers should include multiple joints to be able to grasp and hold aloft different objects. The hardware design for the robotic hand and arm system does not include any size, weight, or power requirements, but should be designed to accommodate a versatile set of fixed or mobile robot platforms. The hardware development is expected to be about 70% of the effort, while the software processing is expected to be about 30% of the effort. The key software development task is the control system to move the hand around to receive tactile input, and output an object's identification from a set of objects (minimally a block of wood, brick, stuffed animal, and feather).

PHASE I: Design a robotic hand system, focusing on the skin and muscle hardware requirements for tactile and force feedback information to be relayed to a central processor, which will then identify objects based on tactile feedback. Estimate system development cost.

PHASE II: Build a prototype using the design from Phase 1. Perform the "Tactile Object Recognition" task. Measure performance by percentage of objects correctly identified.

PHASE III DUAL USE APPLICATIONS: Develop robotic hand systems and apply the technologies toward commercial and military applications, including sorting inventory, automating production lines, or exploring hazardous environments.

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KEYWORDS: Robotic Hands, Mobile Robots, Robot Tactile Systems, Command and Control Systems.

SB093-006 TITLE: Real-Time Autonomous Reasoning for Satellite Defense

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Research and develop on-board spacecraft software technologies to autonomously plan and execute guaranteed real-time responses to dynamic situations and missions.

DESCRIPTION: Satellites have become an increasingly important link in military command, control, and communications approaches, providing mission-critical intelligence, surveillance, location, and communication functions. Advances in anti-satellite technologies have highlighted the vulnerability of these critical links [1]—existing satellites have little or no defensive capabilities, and are controlled largely through slow, ground-based operations centers that cannot react quickly to rapidly-evolving situations.

On-board autonomy will be a critical element in any future satellite defense capability—space systems must meet tight response times to detect and respond to threats and opportunities. A key autonomy function will be the ability to plan and execute defensive actions in real-time, avoiding or defeating threats as they occur. However, developing a comprehensive planning and execution system is very difficult due to the complexity of spacecraft systems and their environment, the range of threats and opportunities, the small timescales involved, the limited onboard computational resources, and the potential harm which can result if incorrect actions are performed. Space applications are particularly complicated by inherently non-renewable resources such as fuel and one-shot devices. Autonomy systems must be verifiably correct and timely, so that their operations can be trusted with critical decision-making [4].

To date, autonomous systems that have flown in space have been highly customized to individual missions, have focused largely on science objectives [2] and maintenance [3], not defense, and have little of the verifiable, high-speed planning and response capabilities required [5,6]. This topic seeks to develop and demonstrate a robust, reliable, verifiable approach to on-board satellite autonomy, emphasizing technologies to perform response planning and action execution. Other elements of a full autonomous satellite defense solution, including sensor processing, event detection, and response actuators, are not the focus of this topic.

PHASE I: Design and demonstrate a verifiable system concept that can perform autonomous planning and reactive action execution in response to real-time detection of threats and opportunities for selected mission scenarios. Low-fidelity simulation models may be used for validation and demonstration.

PHASE II: Develop a full implementation of the architecture designed in Phase I, incorporating higher-fidelity models, more mission scenarios, and realistic simulations. This phase will target a set of realistic scenarios and operating constraints. Phase II will culminate in a high fidelity prototype demonstration of the system.

PHASE III DUAL USE APPLICATIONS: Military applications: Planning for and responding to events is applicable to the Space Superiority and Responsive Space missions. Also, this research will apply to autonomous systems in non-space systems including Future Combat Systems and related ground, air, and water autonomous systems. NASA applications: Increased science and decreased cost via autonomous control of science data acquisition and response to detected events, for both Earth-orbiting and deep space missions. Commercial applications: Planning for and responding to events is applicable to many other domains requiring autonomy, including autonomous aircraft and ground vehicle operations for civilian applications ranging from agriculture to science to firefighting and law enforcement. This research will also relate to automatically controlling response to disturbances in industrial control applications ranging from refineries to power generation.

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KEYWORDS: Autonomous Reasoning, Satellite Defense, Planning and Execution

SB093-007 TITLE: Automated Collaboration Sensors for Networked Command and Control

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

OBJECTIVE: Develop and test sensor technology to collect real-time data on collaborative performance in distributed networked command centers.

DESCRIPTION: Future command centers will oversee networked operations that take maximum advantage of both centralized and distributed decision making, and combine traditional hierarchical military organizational structures with flexible self-organizing units formed for special purposes (Alberts and Hayes, 2003). Coalition operations will require the ability for diverse command teams to work together and coordinate across differences in doctrine, training, and standard operating procedures. To function effectively in this diverse rapidly changing environment, tomorrow's command centers must be collaborative—able to communicate effectively in order to adapt their behavior appropriately as a mission unfolds.

Technology is needed to automatically and unobtrusively obtain data to compute measures of effective collaborative performance. Data will be used to compute leading indicators of command center performance—providing the command team with real time awareness of whether their collaboration is succeeding or failing, and indicating when, where, and how they should change their collaborative behavior to improve their effectiveness.

Technology for automated sensing of collaborative performance may come from any of several research areas. For example, natural language processing technology can analyze communications data from text messages, chat, and transcribed verbal communications to identify communication patterns that are associated with effective team performance (Gorman et al., 2003). Digital sensors worn like ID badges can serve as "sociometers" (Pentland, 2008) that analyze location, physical proximity, tone of voice, and other factors that may be associated with effective collaboration. Psychophysiological and neurophysiological data have the potential to reveal patterns in individual cognitive processing that are associated with effective collaboration (Schmorrow and Kruse, 2004). Proposers need not be limited by this list, but must make the case as to how their proposed senor technology will detect patterns in human performance that are associated with effective collaboration among a diverse distributed command team.

The goal of the research will be to develop, demonstrate, and test sensor technology capable of automatically generating human performance data that can be used to evaluate the effectiveness of collaborative command and control.

PHASE I: Identify a sensor technology that can provide data to compute leading indicators of effective collaboration and develop a conceptual model of how the data would be used in collaboration measures. Develop a proof of concept demonstration of the sensor technology and the use of the data obtained via the sensor, sufficient to illustrate the idea and show its feasibility.

PHASE II: Develop the Phase I technology prototype and validate its performance in assessing collaboration in an experimental setting relevant to command and control. Target Phase II TRL: 5.

PHASE III DUAL USE APPLICATIONS: Complex, diverse global organizations are increasing in incidence, size, and complexity in both the government and private sectors. Cross-team, cross-agency, and cross-cultural collaboration is increasing as a factor for organizational success. Noninvasive technology that can collect data for assessing collaboration will have broad applications in diagnosing problems and improving organizational effectiveness in private companies doing business globally, non-government organizations, and coalition task forces. Complex, diverse global organizations are increasing in incidence, size, and complexity in both the government and private sectors. Cross-team, cross-agency, and cross-cultural collaboration is increasing as a factor for organizational success. Noninvasive technology that can collect data for assessing collaboration will have broad applications in diagnosing problems and improving organizational effectiveness in private companies doing business globally, non-government organizations, and coalition task forces.

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KEYWORDS: Collaboration, Command and Control, Coalition Operations

SB093-008 TITLE: Foveated Vision Technologies

TECHNOLOGY AREAS: Information Systems, Battlespace

OBJECTIVE: Identify and develop an innovative 360° x 20° wide field of view imaging system that incorporates foveated zoom capability and is fabricated without having numerous cameras, gimbals, or mechanically moving large parts, while significantly reducing the size, weight, and power compared to conventional imaging technologies. In order to prevent the loss of any important contextual information, simultaneous viewing of the high resolution foveated image and the entire 360° scene must be carried out in real-time. In addition, targeting capabilities need to be established such that the foveated zoom can be arbitrarily and rapidly directed to anywhere in the 360° scene.

DESCRIPTION: Increasing demands on the soldier for situational awareness require optical imaging techniques to gather information over large fields of view. An urgent need is emerging for future military optical imaging systems to be able to perform foveation on a scene, i.e. there is a need to be able rapidly zoom into one and in some cases multiple areas of a scene simultaneously without losing overall contextual information. This is especially true in urban areas where at least 360° × 20° coverage is required.

The current state of the art foveation schemes are becoming vastly inadequate in meeting current and future size, weight, and power requirements, because they either utilize gimbals (moving lenses mechanically) and/or incorporate multiple cameras. Any single imager Wide Field of View (WFOV) foveation device that incorporates gimbals is very expensive in terms of power, weight, size, and speed, and most importantly, suffers from situational awareness issues (cannot see the whole scene and a foveated image at the same time). Multiple camera solutions are problematic in that size, power and cost scale directly with the number of imagers and high resolution data is captured at all times even in areas of low interest, which greatly increases the computational overhead.

In order to meet the requirements for practical use in a military environment, the proposed device will need to achieve the following specifications:
- Field of view: 360° × 20° (or greater)
- Foveated image acquisition time: < 100 ms with 30 ms desired
- Foveated image resolution: 50% MTF @ 400 lp/mm
- Magnification of 10X of the foveated portion of image

There are numerous approaches which may be developed to achieve the desired specifications for a next generation 360 degree foveated imaging system. Innovative approaches are sought which can achieve all of the requirements simultaneously.

PHASE I: Develop initial concept design for a device that assesses the potential for size, weight, and power reduction while achieving the specified capability. Model key elements to show technical feasibility of a device with one or no moving parts. As part of the final report, plans for Phase II will be proposed which shall include a description of the likely cost, in quantity, of producing such a device.

PHASE II: Finalize design from Phase I and construct a reduced-footprint foveated imaging camera prototype that can be tested in a limited outdoor setting. Fabrication techniques to enable ultimate manufacturing will be assessed. Operation over military temperature ranges and with shock and vibration will be assessed. The prototype must demonstrate achieving the specifications listed in order to progress on to Phase III.

PHASE III DUAL USE APPLICATIONS: In this phase the WFOV imager will be fabricated in a military package and demonstrated in a test environment aboard a military vehicle. The details of the demonstration shall be negotiated between the customer and contractor during Phase II. Further a slow rate manufacturing process and capability will be developed. There are both commercial and military applications for this technology. Commercial applications include: medical and industrial inspection systems, and portable optical imaging systems. Military applications include: surveillance for unattended sensors/motes and robotics, vehicle navigation, imaging for missiles, unmanned airborne vehicles (UAV) based overhead surveillance.

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KEYWORDS: 360 Degree Scanner, Foveation, Zoom, Wide Field of View, Optical Imaging

SB093-009 TITLE: Widely-Tunable Photonic Millimeter Wave Generator

TECHNOLOGY AREAS: Sensors, Battlespace

OBJECTIVE: Identify and develop innovative technology to enable a frequency agile millimeter wave generator tunable from 30 GHz to 120 GHz supporting communications with transmission ranges up to 5 km and data rates of >1 Gbps.

DESCRIPTION: The short wavelengths associated with millimeter waves enable high baseband throughput, very high antenna gain and relatively small antennas. This enables high speed, high directivity portable links. Applications of interest to the military include:
- High directivity, wideband links with enhanced immunity to electronic countermeasures which can be used from either stationary or moving platforms.
- Compact, hand held or helmet mounted and binocular systems for wideband transmission of ultra high resolution surveillance data
- High precision/high selectivity sensor networks (man-to-man, man-to-equipment, equipment-to-equipment)
- Combined optical/millimeter wave (MMW) diversity technique for high availability LOS free space links
- High resolution scanning and targeting

Existing commercial MMW implementations use small form factor, mid- power MMW generators based on solid-state IMPATT and/or GUNN diodes in high precision resonant cavities. These cavities essentially make them non-tunable, difficult to modulate and create serious challenges for high density integration of component chains on integrated circuits using VLSI techniques. This leads to higher cost and larger physical footprints. These systems currently operate at 1.25 Gbps over distances around 100 m to 1 km at fixed frequencies in the 94 GHz and 72 GHz bands; and 10 m to 50 m in the 60 GHz band. Some R&D systems have begun to demonstrate data throughput up to 10 Gbps attempting to reach distances up to 500 m.

Future portable/mobile military MMW equipment may have to become multifunctional and be able to utilize frequency bands in an agile, flexible manner. This may be due to growing network congestion or more likely to enable agile switching between applications optimized in diverse frequency bands. For example, the large range of atmospheric attenuation over the millimeter wave bands allows an agile user to flip between higher attenuation short range applications or lower attenuation, longer range applications like rapid deployment of high speed access links. Also, more widespread application of cognitive radio techniques has frequency agility as a prerequisite.

Techniques for small footprint portable MMW transmitter that will enable broad tunability over the frequency range of 30 GHz-120 GHz with a path to extend the range to 300 GHz are desired. The transmission distance for the low attenuation bands should be >1km with a path to achieving 5km. The net MMW transmit power should be >+10 dBm with a path to >30 dBm. Antenna gains of ~50 dBi are required. Data rates up to 10 Gbps are targeted.

PHASE I: Design of a widely tunable 30-120 GHz MMW generator which also has >10dBm output power. Detailed component specs and designs will be identified. Tradeoffs of key components and system power budgets and tunable range will be made. As part of the final report, plans for Phase II will be proposed.

PHASE II: Implement the detailed design of the key components and MMW generator subsystem specified from Phase I. A concept demonstration prototype of a simple end-to-end link at 5 Gbps, with a tunable carrier frequency over a range of at least 72-160 GHz, transmitting over 1 km transmission range at 120 GHz with acceptable bit error rate (to be proposed), and consuming minimal (less than 60W) system power will be demonstrated. The minimum technology readiness level is 4 “component and/or bread-board validation in laboratory environment,” with stronger proposals targeting or having a clear path to level 5: “component and/or breadboard validation in relevant environment.”

PHASE III DUAL USE APPLICATIONS: Tunable full duplex portable MMW links will be demonstrated in a real field environment and all component design and sourcing issues will be resolved. The proof of concept link should be +20dBm at the output, have 5 km range at 120GHz and be tunable from 30-160 GHz. Along with military applications, less spatially directive mobile links could support the commercial trends toward mobile data transfer for applications such as high definition television, high-quality videoconferencing, and displays with advanced capabilities, which might include three-dimensional viewing, multiple sensory feeds, or virtual reality for telemedicine.

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KEYWORDS: Millimeter Wave, Communication links

SB093-010 TITLE: High Sensitivity/Throughput Biosensor for Bioagent Detection and Identification

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: Develop a high sensitivity, low false-positive rate, and portable integrated chip-scale bio-agent detection platform that exhibit superior performance to current state-of-the-art sensors bio-sensors for bio-agent threats defined by the performer.

DESCRIPTION: The increasing availability and sophistication of biological weapons technology has made it more challenging to defend against biological warfare. Modern biological agents are effective in very low doses; thus, there is a growing need for bio-sensors with an excellent combination of sensitivity, probability of correct detection, and low false positive rate. Additionally, the need for portable rapid detection systems in many applications requires that these sensors have superior size, weight, and power (SWaP) requirements. One promising approach to developing sensors with improved detection and SWaP characteristics is by exploiting integrated chip-scale sensors.

This topic seeks novel approaches to developing integrated chip-scale sensors to detect and classify bio-agents with superior detection and SWaP performance. There is a wide variety of potential pathogens and classes of pathogens that may be considered – with each threat potentially having unique or specific means for sensing and metrics for evaluation and processing. Proposals for any well-motivated threat detection environments will be considered, including water- and air-borne pathogens, as well as those that are detectible in human products. Consequently, this topic is not specific to any particular type of threat, but rather is open to any well-motivated combination of threat and assay approach that utilizes integrated chip-scale technology to achieve dramatic performance enhancements in speed and portability. Proposals should therefore first identify bio-agent threat types where the proposed integrated chip-scale sensor technology can be applied. Proposals should then present a novel bio-sensor design that can out-perform current state-of-the-art sensors in detection and SWaP characteristics for the bio-agent threat type of interest. Performance metrics for the new sensor technology should be proposed that are specific to the threat and that exceed the current state-of-the-art.

In an effort to guide proposals to this topic, below is an example set of a proposed bio-agent threat and detection metrics. This set is meant to be illustrative only – proposals should present their own metrics specific to the bio-agent threats they address:

Sensitivity of better than 10 pM; Scalability to achieve parallel detection throughput > 100,000; Detection specificity better than 0.9 @ low throughput (~10) and better than 0.995 at high throughput (~10,000); Speed of operation ~ 1-100 msec at high concentrations of analyte; Volume of analyte, < 1 nl; operation of the sensor microsystem with false positives rate better than 1/week @ 1000 samples/week; ability to operate with dynamic monitoring @ sampling rate better than 100 samples/sec; Sensor power consumption < 100 mW, volume < 50 inch¬3 and weight < 5 pounds for high throughput operation.

PHASE I: Complete a conceptual design and demonstrate feasibility of biosensor system for biological threat agent detection. To demonstrate feasibility, a test of signal acquisition in the detection of selected bio-agent simulants should be conducted. Concept should be evaluated for detection with a high degree of specificity.

PHASE II: Develop and demonstrate a prototype of a bio-sensor microsystem. Conduct tests in a controlled environment possessing various concentration levels of (a) individual bio-agents and of (b) mixed bio-agent species. A bio-agent response library will be established and evaluated for each bio-agent the system is designed to detect. Portability, stability, repeatability and employability of sensor system would be evaluated and improved. At the end of Phase II, the Transition Readiness Level (TRL) of this technology will be rated as “4 – Component and/or bread-board validation in laboratory environment”.

PHASE III DUAL USE APPLICATIONS: The developed biosensor has potential use in numerous applications, particularly in environmental evaluation systems. Various commercial industrial hygiene applications may also benefit from this development. Biomedical applications will also benefit from this sensing system.

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KEYWORDS: Detector, Sensor, Biosensor, Chemical Sensor

SB093-011 TITLE: Ultraviolet (UV) Imaging Focal Plane Arrays

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop focal plane array technology for solar blind UV imaging, with detector size of approximately five (5) microns and read-out integrated circuit (ROIC) designs consistent with state of the art imaging array technology, establishing the basis for mega-pixel UV arrays.

DESCRIPTION: Ultraviolet imaging arrays capture unique target signatures, which provide critical information for several application areas. Applications include machine vision, solar blind imaging, and in chemical and biological applications for detection of surface residues and biological agents. In these applications the generation of high quality images, with characteristics comparable to commercial imaging technology will enhance the utilization of ultraviolet imaging. This program leverages recent advances in UV sensitive material and detector technology, and focuses on UV imaging focal plane array technology through optimization of the detector design and development of design concepts for the integration of UV detector arrays with state of the art read-out electronics for imaging.

The high resolution inherent in UV imaging can be enhanced through development of an array technology with small size detectors, an enabling component for megapixel imaging arrays. Pixel size on the order of five microns is the desired goal. The program will address the technical issues associated with producing small pixel size UV detectors, including improved surface control, high quantum efficiency, high responsivity to maintain signal-to-noise in the integrated detector-read-out, and uniformity across large areas. High speed imaging applications may also require gain in the detector with low excess noise. Goals are signal-to-noise greater than ten (10) and responsivity uniformity of 10 % across mega-pixel arrays.

Read-out integrated circuit (ROIC) design concepts will be developed for efficient injection of charge from the detector and with the characteristics associated with state of the art imaging. High dynamic range, an important consideration in all imaging applications, will be included in the read-out design, with a goal of 60 – 80 db. Concepts for on-FPA image processing tailored to UV imaging will be included may also include local area contrast enhancement and windowing functions to read-out data at higher frame rates, on the order of 1KHz.

Models will be developed to understand characteristics of small pixel size UV detectors and mechanisms for gain in the detector. A small prototype array will be demonstrated to verify capability of the detector design and compatibility with the ROIC concept.

PHASE I: Develop small pixel size UV detector test arrays, evaluate characteristics, and compare experimental results with theoretical model. Establish design concepts for the ROIC to assess on-focal plane processing features that can be included in unit cell size ranging from as large as 30 um to 5um unit cells. Plans for Phase II will be established to demonstrate UV imaging focal plane array, with format 64x64 or larger.

PHASE II: Select and finalize the best pixel and ROIC designs achieved in Phase I, in order to optimize performance parameters through experiments. Demonstrate the feasibility of large area arrays with small pixels through characterization of array uniformity across the wafer. Characterize broadband response to evaluate essential detector characteristics, such as quantum efficiencies and gain in the UV bands. Show a path for extension of the ROIC design to small pixel size required for high resolution mega-pixel arrays. Required Phase II deliverables will include an ROIC design concept and detector test arrays with complete characterization report.

PHASE III DUAL USE APPLICATIONS: Several units of the UV APD arrays will be manufactured and a series of qualification tests will be performed to validate the design and its performance. This technology has broad applications in military and various commercial sectors. The commercialization of this technology is expected to provide low cost, high performance mega-pixel imagers for potential uses in applications such as security/law enforcement, medical imaging, homeland security as well as military applications such as multipurpose imaging, Missile Threat Warning, chemical & biological detection, etc.

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KEYWORDS: Small Unit Cell APD, UV Array, High Resolution Imaging, Threat warning,

SB093-012 TITLE: Fast, Narrow Linewidth Near Infrared (NIR) / Shortwave Infrared (SWIR) Scanner

TECHNOLOGY AREAS: Sensors, Battlespace

OBJECTIVE: Develop fast, continuously tunable scanner capable of simultaneously maintaining narrow spectral linewidth comparable to that of fixed-frequency devices and exceeding the tuning speed of 10GHz/ns.

DESCRIPTION: The endurance of aerial vehicles critically depends on the efficiency and performance of its propulsion system. Jet propulsion in unmanned aerial vehicles poses simultaneous challenges of low consumption and fast thrust response. Real-time monitoring and control of such combustion process requires1 near-instantaneous acquisition of its spectral signatures. Similar bursty and explosive processes, while lasting very short time, generate high information volume that needs to be captured in real time. An advanced jet turbine operating at 120,000 rpm generates wideband spectral signature over hundreds of nanometers range; cycle-resolved monitoring of comparable turbine can be performed by narrow-linewidth, continuously tunable source and a single detector device. The combination of very fast, continuously tunable source and high-speed detector is capable of spectral information rates exceeding those of the conventional spectrometers by at least an order of magnitude2.

Spatially resolved techniques such as Optical Coherence Tomography (OCT), provide real-time analysis in medical, manufacturing and sensing applications and critically depend on the performance of continuously tunable source3: OCT resolution is a direct function of source tuning speed and source linewidth. Advanced source3 relies on mechanical scanning and is capable of millisecond-scale tuning over 70nm, while maintaining the linewidth of 15GHz. While the source represents significant improvement over the past technology, the micrometer resolution barrier still remains. More importantly, new devices must be devised in order to address packaging and power consumption compatible with SWAP parameters expected from the field or ultraportable units.

The new tuning technology must offer high figure of merit that combines large tuning speed, narrow linewidth and wide spectral range. The new development must overcome the basic obstacle set by interdependence of source linewidth and achievable tuning speed: while the source tuning must be slower than the cavity lifetime, its linewidth is inversely proportional to the cavity lifetime. Any new development thus must overcome this technological barrier to provide source that simultaneously possesses fast tuning speed and narrow linewidth over practically useful spectral range.

Recent demonstration of tuning and linewidth-impairing mechanisms have demonstrated new path towards the construction of fast tunable sources. However, significant practical challenges remain on path to deployable technology:
Effective tuning range decoupling from linewidth and scan speed in practical source design; Practically useful power output scaling that is independent on tuning speed, source linewidth or operational spectral range.

If the practical design successfully decouples the tuning range, speed and linewidth, the resulting device would provide unfettered access to real-time acquisition of fast and explosive processes and provide in-vivo insight into biological microsystems for the first time. More importantly, the source would be a critical block for the next generation of spectrometers, sensors and combustion controlling mechanisms.

PHASE I: Develop a practical design for a fast, continuous tuning source with narrow linewidth over conventional NIR and SWIR bands. Derive engineering rules and state expected SWAP parameters.

PHASE II: The design from Phase I will be finalized and subcomponent tested. The validation of proposed source architecture will be quantified using the testbed assembly. The prototype unit will be derived from the testbed and manufactured under frequency agile and frequency stable operating conditions.

PHASE III DUAL USE APPLICATIONS: Multiple units of tunable source will be assembled and tested under dynamic and environmental loads appropriate to laboratory and extreme (field) conditions. Two separate applications (commercial/military) will be targeted by specifically designing the fieldable units.

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KEYWORDS: Fast Spectroscopy, Spectral/Spatial Scanners, Tunable Sources, Combustion Control, Explosive Monitoring.

SB093-013 TITLE: Inexpensive, Portable Sensors for Chemical-Biological Agent Detection

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: Develop inexpensive, hand-held chemical and biological agent sensors utilizing the latest technologies available, including gas chromatography, spectroscopy and other spectral-scanning techniques. These sensors would have novel algorithms embedded, so that the presence of individual agents can be detected quickly.

DESCRIPTION: Chemical and biological agents are threats within the battlefield and to our homeland security. Although these threats are being addressed by the initiation of new sensor development programs, which employ sensitive detection methods and sophisticated analysis capabilities, the result is that such instruments are large and require the participation of experts for their function and analytical output. In addition, these instruments can only be deployed selectively because of their cost and supporting requirements. There is a need for inexpensive sensors capable of acquiring, analyzing, and rapidly determining the presence of such threats with reasonable certainty of making the correct identification. The choices at present, such as instruments based upon gas chromatographic and spectroscopic analyses are costly and bulky – making ordinary deployment impractical.

There is the potential for developing portable hand-held devices exploiting alternative technologies, such as optical scanning and other spectral decomposition methods, which offer opportunities for a cost-effective method for analysis of chemical and biological threats, with reasonably low false-alarm rates. However, novel data processing algorithms will need to be developed for rapid identification of the chemicals and their ongoing reactions - even in low concentrations. These algorithms should analyze plumes in terms of shape, particle size, concentration, fluorescence and other physical and chemical parameters, increasing the probability of detection and decreasing the false alarm rate. In addition, scanning technology and its accompanying image processing techniques must be modified and miniaturized for hand-held deployment. The goal is to simplify the method of sampling the physical and chemical features of a suspected chem/bio emission, to provide an analysis capability based upon newer spectroscopic methods and processing techniques, and provide an immediate identification of the suspected threat constituents which can be sufficient for a non-expert user to take an appropriate action.

This SBIR would solicit proposals to explore potential techniques to meet those ends. The end-product goal would be an inexpensive ($300, in quantity), portable chemical-biological agent detector for military field use.

PHASE I: The following would be the expected effort and results of the Phase I effort:
- Explore the current advances in optical and other scanning techniques for application in hand-held assay analysis.
- Produce an approach where the current scanning technologies can be modified and miniaturized for portable and cost-effective operation.
- Develop pattern recognition methods to aid in such analysis.
- Establish novel algorithms for rapid processing of hand-held assays.
- Describe a plan where portable chemical sensor can be deployed in both the battlefield and homeland security scenarios.

PHASE II: For Phase II, a well-defined prototype portable chemical sensor would be delivered for field test to detect some common chemical and biological agents, culminating in a well-defined deliverable prototype.
- Advance the concepts derived from Phase I into designs of portable chemical sensors for fabrication.
- Establish performance parameters for these sensors to include detection of common chemical and biological agents.
- Assemble prototypes of these sensors and demonstrate their validity.
- Explore effectiveness of these prototype sensors to include more types of chem-bio agents through experiments.
- Conduct field tests to demonstrate the operational capability of these prototypes.
- Finalize the design of the prototypes in preparation for volume production.
- Determine life cycle and environmental issues of the sensors.
- Required Phase II deliverables will include operational prototypes of several designs of chemical and biological agents suitable for military and homeland security deployment.

PHASE III DUAL USE APPLICATIONS: Phase III derives from, extends, or logically concludes efforts performed under SBIR. A military application would be for a dismount to carry a portable chemical sensor into a combat zone where chem.-bio agents may be deployed by our adversaries. A commercial application for this technology would be for civil defense deployment where domestic terrorist may resort to using poisonous chemicals.

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KEYWORDS: Chemical Sensors, Stand-off Detection, Aerosol, Embedded Algorithms, Hand-held Assay.

SB093-014 TITLE: Energy Collection and Storage Systems for Re-Entry Modules

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Identify and develop innovative energy collection and storage systems suitable for use on re-entry modules.

DESCRIPTION: DARPA is interested in developing the technologies necessary for the collection and storage of a portion of the energy available from the re-entry of an orbiting space module. This collection system must be compact, scalable, and capable of collecting and storing this energy for an extended period of time for re-use in an alternative purpose, such as propulsion of an aircraft or power for a sensor system. Example concepts include magnetohydrodynamic conversion and thermal storage. Other concepts welcome. The important metrics of the overall system are efficiency and weight of the energy collection system, and energy/kg of the storage system. The threshold goal is to capture and store 5% of the system's orbital energy (kinetic and potential) with an objective goal of over 10%. The ability of the concept to be stowable within a standard fairing is important as is the capability of integration of complete system or just the energy storage subsystem into an aircraft or sensor pod.

PHASE I: Conduct an analysis and feasibility study of potential scalable approaches to provide a low weight re-entry energy collection and storage system and estimate the efficiency and weight of the energy collection system, and Whr/kg of the storage system. Demonstrate that the proposed system is scalable and can survive the environmental requirements necessary to collect and store energy during the re-entry phase. Identify key materials and sub-systems requiring development and present a credible plan to accomplish these tasks.

PHASE II: Develop the materials and sub-systems identified in Phase I and demonstrate the energy collection and storage performance at subscale using a simulated re-entry thermal load and flux at an appropriate pressure and temperature environment.

PHASE III Dual Use Applications: The technology developed under this SBIR can be used in military and civilian commercial applications such as emergency power collection.

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KEYWORDS: Space, propulsion, re-entry, energy conversion, power storage