DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the second fiscal year (FY) 2003 solicitation (FY 2003.2). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although the topics are unclassified, the subject matter may be considered to be a "critical technology". If you plan to employ NON-U.S. Citizens in the performance of a DARPA SBIR contract, please identify these individuals in your proposal as specified in Section 3.5.b(7). These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included followed by full topic descriptions. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

DARPA **NOW** requires electronic submission of Cover Sheets, Technical and Cost proposals, and Company Commercialization Report. A hardcopy is no longer required. Only proposals submitted through the on-line submission site at www.dodsbir.net/submission will be accepted or considered for award.

HELPFUL HINTS:

1. Consider the size of the proposal to allow sufficient time for uploading.
2. Perform a virus check.
3. Signature is no longer required at the time of submission.
4. Submit a new/updated Company Commercialization Report.
5. Please call the Toll Free SBIR line for submission problems: 866-724-7457
6. DARPA will not accept proposal submissions by electronic facsimile (fax).

DARPA Phase I awards will be Firm Fixed Price contracts.

Phase I proposals shall not exceed $99,000, and may range from 6 to 8 months in duration. Phase I contracts can ONLY be extended if the DARPA Technical Point of Contact wants to "gap" fund the effort to keep a company working while a Phase II proposal is being generated.

DARPA Phase II proposals must be invited by the respective Phase I DARPA Program Manager (with the exception of Fast Track Phase II proposals – see Section 4.5 of this solicitation). 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.

It is expected that a majority of the Phase II contracts will be Cost Plus Fixed Fee. However, DARPA may choose to award a Firm Fixed Price Contract or an Other Transaction, on a case-by-case basis.

Prior to receiving a contract award, the small business MUST be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-888-352-9333 and pressing 3 or Internet: www.ccr.gov.

The responsibility for implementing DARPA's SBIR Program rests in the Contracts Management Office. The DARPA SBIR Program Manager is Ms. Connie Jacobs.

SBIR proposals will be processed by the DARPA Contracts Management Office and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. **TRANSITION OF THE PROPOSED EFFORT IS**

VERY, VERY IMPORTANT. THE SMALL BUSINESS SHOULD INCLUDE THEIR TRANSITION VISION IN THEIR COMMERCIALIZATION STRATEGY. THE SMALL BUSINESS MUST UNDERSTAND THE END USE OF THEIR EFFORT AND THE END USER, i.e., ARMY, NAVY, AF, SOCOM, ETC.

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 proposal(s) is deemed superior, 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.

Cost proposals will be considered to be binding for 180 days from closing date of solicitation.

Successful offerors will be expected to begin work no later than 30 days after contract award.

For planning purposes, the contract award process is normally completed within 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

The DoD SBIR Program has implemented a Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. DARPA encourages Fast Track Applications ANYTIME during the 6th month of the Phase I effort. The Fast Track Phase II proposal must be submitted no later than the last business day in the 7th month of the effort. **Technical dialogues with DARPA Program Managers are encouraged to ensure research continuity.** If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding will generally not exceed $40,000.

To encourage the transition of SBIR research into DoD Systems, DARPA has implemented a Phase II Enhancement policy. Under this policy DARPA will provide a Phase II company with additional Phase II SBIR funding, not to exceed $200K, if a DARPA Program Manager can match the additional SBIR funds with DARPA core-mission funds or the company can match the money with funds from private investors; or at the discretion of the DARPA Program Manager. DARPA will generally provide the additional Phase II funds by modifying the Phase II contract.

Distribution Statement “A” (Approved for Public Release, Distribution Unlimited).

DARPA FY2003.2 Phase I SBIR
Checklist

Page Numbering

Number all pages of your proposal consecutively _____
Total for each proposal is 25 pages inclusive of cost proposal and resumes
Beyond the 25 page limit do not send appendices, attachments and/or additional references
Company Commercialization Report **IS NOT** included in the page count

Proposal Format

b. Cover Sheet, Technical and Cost proposals, and Company Commercialization Report MUST be submitted electronically _____

c. Identification and Significance of Problem or Opportunity _____

d. Phase I Technical Objectives _____

e. Phase I Work Plan _____

f. Related Work _____

g. Relationship with Future Research and/or Development _____

h. Commercialization Strategy _____

i. Key Personnel, Resumes _____

j. Facilities/Equipment _____

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DARPA SB032-027	Micro Systems Vacuum Packaging
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DARPA SB032-030	Application of Inexpensive Microsensors to the Battlefield
DARPA SB032-031	Lightweight Multifunctional Space Vehicle Structures
DARPA SB032-032	Overpressure Primary Blast Wave Characterization and Countermeasures for Personnel Protection and Human Vulnerability
DARPA SB032-033	Adaptive Structures Applications of Piezoelectric Single Crystals
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DARPA SB032-044	Wide Bandgap Semiconductors Materials, and Devices
DARPA SB032-045	Maskless Lithography for Fabrication of Microelectronics with 100 nm Features
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DARPA SB032-048	Unconventional Space Power
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DARPA SB032-026 TITLE: Finishing of Conformal Optics in Hard Materials

TECHNOLOGY AREAS: Materials/Processes, Weapons

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OBJECTIVE: The objective of this program is to demonstrate a novel technique for finishing atypical conformal optical surfaces, particularly in hard materials such as Aluminum Oxynitride (AlON). Conventional finishing techniques are not suited for deep spheres or aspheres where reaching into a concave cavity is required. In addition, techniques such as magneto-rheological finishing (MRF) are not well suited for large grain, hard materials such as AlON.

DESCRIPTION: Conformal optics is an exciting new capability previously demonstrated under a DARPA effort. Conformal optics offer many advantages in critical applications where the optimal surface shape is determined by non-optical criteria. For example, high performance missile domes and aircraft windows have optimal shapes determined by aerodynamic, rather than optical, considerations. Conformal optics is a new class of optics that makes such optimal solutions possible. In many cases, however, the inside of the dome is relatively deep making it very difficult or impossible to finish with conventional techniques. Even some spherical domes have relatively deep, concave surfaces that inhibit conventional finishing methods. New technologies, such as MRF, offer possible solutions but are not well suited for all materials. Recently, AlON has received considerable attention as a candidate material for missile domes. AlON is a very durable material that is resistant to impact damage, has good erosion resistance, and acceptable thermal shock resistance. The high hardness of AlON also makes it a time consuming process to shape and finish. Recent efforts have attempted to reduce the cost of AlON domes through a combination of deterministic and conventional processes. Much progress has been made in generating the dome; however, the final finishing remains an issue. Studies conducted by the Center for Optics Manufacturing have shown that the large grain size and the grain orientation dependent hardness of AlON make it very difficult to finish using MRF. Subsurface damage can and does play a critical role in the strength of the material and must be minimized or eliminated through finishing. Grain decoration became an issue when trying to remove the subsurface damage using MRF. The goal of this effort is to develop new techniques, processes, and hardware to enable finishing of hard materials, such as AlON, in a timely and cost effective manner.

PHASE I: This effort is to study the feasibility of the proposed approach to meeting the goals set forth in the objective, i.e., developing the capability to optically finish deep concave surfaces in hard optical materials. The approach must be compatible with the manufacturing environment. The study will consider the need to finish the inside and outside surfaces achieving a surface figure of *f*Ü/20 peak-valleys (in the mid-wave infrared) and an rms finish of 25 angstroms or less. Optics up to 6¡¨ in diameter should be considered.

PHASE II: Continue development of the process and techniques developed in Phase I with a demonstration of optical finishing of a deep asphere provided by the Government. The demonstration will be conducted on both the inside and outside surfaces of the optic provided.

PHASE III DUAL USE APPLICATIONS: Candidate dual use applications include finishing of optics for aircraft windows, spacecraft, and submersible vehicles.

REFERENCES:
1. Harris, Dan, "Material for Infrared Windows and Domes," ISBN 0-8194-3482-5, SPIE Press, 1999.
2. Shorey, Aril B., Gregg, Leslie L., Romanofsky, Henry J., Arrasmith, Steven R., Kozhinova, Irina A., Hubregsen, Joshua, and Jacobs, Stephen D., “Material removal during magnetorheological finishing (MRF)” in Optical Manufacturing and Testing III, Phillip Stahl, ed., Proceedings of the SPIE Vol 3782, 1999.

KEYWORDS: Conformal Optics, Optical Finishing, Polishing.

DARPA SB032-027 TITLE: Micro Systems Vacuum Packaging

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: To develop novel, low-cost, reliable, long shelf-life micro packaging systems ideal for resonating Microstructures that require high Q values achieved via vacuum or gas-filled hermetic packaging.

DESCRIPTION: With increasing developments in MicroElectroMechanical Systems (MEMS), miniature sensors are filling the horizon. These tiny sensors offer potential for ultra small, ultra light, very low-cost weapon systems and/or sub-systems. However, significant deterrents to military application of many of these devices exist. Of primary concern for almost all MEMS sensors to date is the issue of packaging. The problem of MEMS packaging is almost as broad a research area as is development of MEMS devices. The package itself couples into the MEMS system and can greatly affect performance. Various package styles and techniques will affect the thermal, Electromagnetic Interference (EMI), mechanical stress, and reliability characteristics of the sensors in various ways. Due to the broad applicability of MEMS devices to so many various systems, there will not be a one-size-fits-all package or universal form of package. But the possibility exists for families of packaging techniques, similar to those found in the microelectronics arena, and several organizations are currently exploring various aspects of packaging by investigating the use of new materials, new processes, new package designs, and new standards.

However, military requirements often strain the capability of commercial-off-the-shelf (COTS) devices and can even impose requirements beyond the capability of existing technologies. For example, even the most mature inertial micro sensors, such as vibratory angular rate and acceleration sensors, are unable to achieve full dynamic range performance in uncontrolled, or unmonitored, environments. In order for these devices to accurately measure the inertial parameters at issue (to military requirements), they must also very accurately determine and/or control their elemental environment such that oscillation perturbations can be attributed solely to the inertial parameters of interest. Furthermore, the sensors must maintain very high reliability over decades of shelf-life. Obviously, as the size of sensors shrinks, so does the volume of the package around the sensor. As the package shrinks, the difficulty of maintaining long-term integrity of a hermetically sealed miniature system greatly increases.

The goal of this topic is to solicit novel and innovative methods for packaging MEMS sensors in vacuum. The sensor system must be able to maintain a 25milliTorr vacuum for a minimum of 10 years. A paradigm shift from microelectronics packaging techniques is expected. System-of-systems concepts should be explored to determine if micro pumps and/or micro thermal controllers could be incorporated as a part of the package for inertial sensors. Proposals should address as many sensor types as possible in accordance with the issues above. Award consideration will be based heavily upon the completeness of addressing the named concerns, the innovative nature of the technology proposed, the economical advantages of the technique(s) proposed, the applicability of the technique(s) to both military and commercial uses, and the performance specifications/expectations of the packaged sensor(s).

PHASE I: Identify specific packaging requirements and common techniques for packaging MEMS inertial sensors. Determine typical micro package outgassing characteristics and generically model specification expectations required for maintaining vacuum integrity for 10, 15, and 20 years (i.e. determine realistic goals based upon the current state of the technology). Describe your packaging concept(s) and disclose the feasibility of the proposed technology(ies) that will provide robust, low-cost, ultra-reliable MEMS sensing devices for military applications. Identify inherent theoretical limitations of, and any technological barriers to implementation of, your design concept (including such parameters as packaging effects on performance, size, reliability, cost, etc.). Identify vendors for fabricating the novel vacuum packaging systems. Identify testing facilities or, in the alternative, demonstrate an in-house capability, to accurately test the integrity and performance of vacuum packages. Quantify the advantages of your approach or conduct proof-of-principle experiments to verify proposed techniques. All devices must ultimately demonstrate reliability over a temperature range of –57 degree C to +95 degree C for a 10-year life.

Phase II: Validate your Phase I concepts by packaging prototype MEMS sensors for military applications. Develop a test plan and methodology for determining the performance, including shelf-life, of your conceptual package design. Teaming with government, industry, or academia foundries as necessary is encouraged. Confirm performance through laboratory testing and quantify performance specifications for the packaged micro-devices.

PHASE III DUAL USE APPLICATIONS: The dual use potential of the product(s) from this effort is phenomenal. While military requirements may exceed many industrial requirements, a paradigm shift in packaging concepts could greatly reduce the cost of packaging while improving performance. Therefore, markets extend from numerous automotive, aeronautical and robotic applications to mining and oil-drilling applications. The potential market sales of packaged, miniature, low-cost sensing devices are astronomical.

REFERENCES:
1. Department of Defense, "Microelectromechanical Systems: A DoD Dual Use Technology Industrial Assessment" December 1995.
2. Lyke, James C., "Packaging for MEMS, MEMS for Packaging" COTS MEMS Advances in Applying Integrated Commercial Off-The-Shelf Micro-Electro-Mechanical Systems. Proceedings of the COTS MEMS Conference August 3-4, 2000, www.knowledgefoundation.com.

KEYWORDS: Packaging, MEMS, Sensors, Micro Sensors, Materials.

DARPA SB032-028 TITLE: Next-Generation Modem Technology for High Threat Environments

TECHNOLOGY AREAS: Information Systems

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OBJECTIVE: Develop next generation modem technology for providing assured military communications in extreme Electronic Warfare (EW) environments, including proliferated, smart EW assets.

DESCRIPTION: Recent breakthroughs in computer hardware (specifically Random-Access Memory (RAM) capacity, processing devices, and speed) have greatly escalated the EW threat to military communications, at a time when the need for robust, wideband military communications is increasing. For example, smart, proliferated, expendable, networked EW devices are enabled by the above technology advances. There is a strong need for new tactical modem capabilities and architectures to counter possible advanced EW systems. The objective of this program is to develop and demonstrate major performance improvements and functionalities applicable to next-generation military radios, exploiting the referenced breakthroughs in computing hardware. For example, it now may be practical to implement in hardware many array and signal processing techniques that, heretofore, could only be simulated and analyzed [1 - 6].

PHASE I: Identify innovative modem architectures that enable operation in harsh EW scenarios. Emphasis will be placed on new capabilities and implementations which facilitate high-data-rate (on the order of 100 megabits per second (Mbps)) low probability of detection/anti-jam (LPD/AJ) communications using smart antennas in highly mobile ad hoc network environments. The work will produce a performance specification for a proof-of-concept modem with major new capabilities supported by simulation results and a baseline design. This design will include a credible estimate of hardware requirements in terms of contemporary digital signal processing devices (e.g. general purpose processor (GPPs), digital signal processor (DSPs), field programmable gate-array (FPGAs), RAM, etc.).

PHASE II: Demonstrate innovative capabilities on proof-of-concept hardware suitable for demonstration with advanced development military communications systems in Phase 3.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in demonstrations of advanced electronic counter-counter measures (ECCM) capabilities and can also be used in commercial applications requiring very high data rate communications.

REFERENCES:
1. R. Lupas and S Verdu, "Linear multi-user detectors for synchronous…," IEEE Trans Inform Theory, vol. 35, no. 1, pp. 123-136, Jan. 1989.
a. http://citeseer.nj.nec.com/context/23082/0
b. http://ieeexplore.ieee.org/servlet/opac?punumber=18

2. R. Kohno et al., "Combination of an adaptive array antenna and a canceller of interference for direct-sequence spread-spectrum multiple-access system," IEEE JSAC, vol. 8, no. 4, May 1990, pp. 675-82.
a. http://citeseer.nj.nec.com/context/178202/0
b. http://ieeexplore.ieee.org/servlet/opac?punumber=49
3. Y.Sanada and M. Nakagawa, "A multi-user interference cancellation technique using convolutional codes and orthogonal multi-carrier modulation for wireless indoor communications," IEEE Journal on Selected Areas in Communication, 14(8):1500-1509, Oct 1996 http://ieeexplore.ieee.org/servlet/opac?punumber=49.
4. Z. Xle et. al, "A family of suboptimum detectors for coherent multi-user communications," IEEE J. Select. Areas Commun., vol. 8, no. 4, pp. 683-690, 5/90.
a. http://citeseer.nj.nec.com/context/59700/0
b. http://ieeexplore.ieee.org/servlet/opac?punumber=49
5. P. Patel and J. Holtzman, "Performance comparison of a DS/CDMA System using a successive interference cancellation (IC) scheme and a parallel IC scheme under fading," Proc. IEEE International Conference on Communications 1994 (ICC '94), New Orleans, LA, pp. 510-514, May 1994.
a. http://ieeexplore.ieee.org/xpl/tocresult.jsp?isNumber=8446
b. http://ieeexplore.ieee.org/xpl/tocresult.jsp?isNumber=8446&page=9
6. Sanada and Q. Wang, "A co-channel interference cancellation technique using orthogonal convolutional codes on multi-path Rayleigh fading channel," IEEE Trans. Vehic. Tech, vol. 46, no. 1 pp. 114-128, Feb.1997 http://ieeexplore.ieee.org/servlet/opac?punumber=25.

KEYWORDS: Electronic Warfare, Low Probability of Detection, Anti-Jam, Smart Antennas, Modem.

DARPA SB032-029 TITLE: High-Efficiency 555-585 nm (Deep Green) Direct-Emission LED

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: Develop high efficiency direct-emission Light Emitting Diode (LED) technology in the 555-585 nm wavelength band, to support full spectrum direct-emission illumination systems for spectroscopic analysis systems, displays, and general lighting systems on military platforms.

DESCRIPTION: Current LED technology cannot efficiently (>20% external electrical efficiency) operate as a direct emission source of light in the 555-585 nm wavelength band. Aluminum Indium Gallium Phosphide (AlInGaP) devices have delivered impressive performance in the yellow through red portion of the spectrum, and gallium nitride (GaN) devices have more recently shown impressive gains in the blue-green to blue regions of the spectrum. But neither of these families of devices has been able to extend to efficient operation in the deep green (555-585 nm), which is coincidentally the peak of the photopic response of the human eye and therefore a key component of any white light source. The current solution is to use a phosphor to cover this region of spectrum, which significantly halves the efficiency and constrains system design flexibility. The development of an efficient direct-emission LED in the deep green requires innovations in device design, and possibly a novel materials system, to avoid the constraints that have limited performance to date. Current state-of-the-art devices are exceeding 20% external quantum efficiency, and a suitable direct-emission deep green LED should be capable of similar efficiency, corresponding to >120 Lumen per Watt.

PHASE I: Determine the feasibility of an efficient (>20% external electronic efficiency) direct emission deep green (555-585 nm) LED design. Develop and analyze detailed designs with industry-accepted models, demonstrating the fabricability of the subject design..

PHASE II: Design, fabricate, and demonstrate a low-power high-efficiency direct-emission LED in the deep green (555-585 nm). Develop scaled device designs for higher power and second generation device designs for improved efficiency.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in a wide range of commercial applications, including handheld displays, spectrographic instrumentation, and ultimately general lighting.

KEYWORDS: Light Emitting Diode, LED, Lighting, Full-Spectrum, Spectroscopy.

DARPA SB032-030 TITLE: Application of Inexpensive Microsensors in the Battlefield

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: Identify methods of utilizing inexpensive microsensors to provide for the protection of armed forces.

DESCRIPTION: Despite enhanced technology and increasing sophistication of our military forces, they have come to have higher vulnerability to attack by individuals or small units possessing grenade launchers and man-pads. It is difficult to counter such attacks, which employ camouflage, concealment and deception, and cannot easily be detected by traditional methods, such as imaging. Unattended ground sensors (UGS) have been utilized with limited success, because of their prohibitive expense. Microsensors, about the size of a nickel or dime, are now being developed which, in quantity, are expected to cost only a few dollars, and provide multiple sensing modalities. Since they have limited battery power, they must communicate in ways that conserve energy and yet avoid detection by enemy forces. Applicants for this topic must: (a) consider a sparse selection of sensor characteristics which could be implemented within restrictions of power and cost; (b) determine means of distribution, density, and practical communication modes with such sensors; (c) provide a quantitative evaluation of the performance of such sensors within a realistic military model, and show how outcomes can be optimized. The goal of this topic is to develop creative approaches for performance evaluation of cheap microsensors, to guide their development and define their emplacement for optimum usage in the field.

PHASE I: Perform an initial assessment of microsensor technologies and suitable communication methods. Provide a first-order simulation of their capability in a selected threat scenario, showing quantitatively how outcomes can be improved.

PHASE II: Perform more general assessments, varying sensor capabilities in a multiplicity of realistic threat models. Examine sensor distribution and communication modes, and evaluate cost/performance for such inexpensive microsensors compared with current sensors.

PHASE III DUAL USE APPLICATIONS: The technology developed in this topic provides commercial utilization, such as business and home protection.

REFERENCES:
1. Micro Sensor Systems Concept of Operations, Annual Report to the Defense MicroElectronic Activity (January 2003), Sacramento CA 95652.
2. Design, Fabrication and Modeling of Microbeam Structures for Gas Sensor Applications in CMOS Technology; I. Voiculescu, M. Zaghloul, and R. A. McGill, in Proceedings of 2003 IEEE International Symposium on Circuits and Systems.
3. DARPA Web Site: http://www.darpa.mil/

KEYWORDS: Sensors, Microsensors, Unattended Ground Sensors, Simulation, Perimeter Protection, Battlefield Models

DARPA SB032-031 TITLE: Lightweight Multifunctional Space Vehicle Structures

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

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OBJECTIVE: Investigate the potential for using integral and addressable magnetogasdynamics as a function of space re-entry vehicle structures.

DESCRIPTION: The Defense Advanced Research Projects Agency (DARPA) is soliciting innovative research proposals in the area of lightweight multifunctional space re-entry vehicle structures. During space re-entry interaction of the space vehicle and the earth's atmosphere results in plasma (ionized air) generation near the re-entry vehicles surface. Introducing an integral and addressable magnetic character into the re-entry vehicle structure might permit use of the plasma layer for heat rejection, power generation, or aerodynamic control. Lightweight multifunctional space vehicle structures could change the paradigm for designing and employing military and commercial space vehicles. The high cost of constructing and launching into orbit space vehicles with bulky and heavy re-entry structures has forced the industry to focus on throw-away systems.

DARPA seeks SBIR Phase I innovative proposals that demonstrate the feasibility of introducing an addressable segmented magnetic character into space re-entry vehicle structures to effect one of the following outcomes: 1) creation of a thermally superconducting material system to channel energy form front to aft of the vehicle with little heat absorption; 2) creation of virtual control surfaces by locally affecting the thickness of the plasma layer; or 3) harvesting plasma energy for power generation. Proposed research should investigate innovative approaches that enable replacement of conventional high-density space vehicle structures such as albative material, hinged controls, and power generators.

PHASE I: Phase I efforts will identify an approach and demonstrate through scientific analysis, modeling, or simple experimentation the feasibility of employing magnetic space vehicle structure to effect one of the three outcomes of interest listed above. Due to the limited resources permitted to support Phase 1 efforts, proposals should address only one of the areas of interest listed.

PHASE II: Phase II will be focused on demonstrating performance of magnetic space structures through laboratory scale experiments. At least one, but desirably all three of the desired outcomes will be proven through experimentation and supporting scientific analysis.

PHASE III DUAL USE APPLICATIONS: This phase of the proposed effort will be aimed at demonstrating how magnetogasdynamics-enabled lightweight, multifunctional space vehicle structures can be transitioned to practical use. A prototyping effort is desired that will resolve issues of manufacturing technology, reliability, and affordability. One or more large or full-scale prototype vehicles will be constructed.

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KEYWORDS: Magnetogasdynamics, Space Re-entry Structures.

DARPA SB032-032 TITLE: Overpressure Primary Blast Wave Characterization and Countermeasures for Personnel Protection and Human Vulnerability

TECHNOLOGY AREAS: Weapons

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OBJECTIVE: To develop and demonstrate protective countermeasures against the primary blast wave of enhanced munitions in a single/multiple closed room environment for a single blast.

DESCRIPTION: Enhanced blast munitions are defined as non-fragmentation weapons which have the potential to incapacitate and eradicate personnel from a greater distance. Examples include fuel air and thermobaric explosives. The primary blast effect is characterized by an overpressure phenomenon combined with an increased exposure due to the duration of the wave. Heat is limited a factor in this effect. The primary blast wave consists of shock, stress and shear waves which may have both direct and indirect effects on internal gas-filled organs. In a closed room

environment the wave becomes a complex wave with specific frequency signatures which may contribute to further organ trauma. Gas filled organs such as the pulmonary, otolaryngology and gastrointestinal systems are at greatest risk, as well as ophthalmic and central nervous system areas. Exposure to blast can potentially overwhelm the medical logistic capability in either a terrorist attack or combat injuries in the battlefield. Defensive mechanisms against enhanced blast munitions have not been a primary focus area of soldier body armor protection. A better understanding of shock wave biophysics in relation to present body armor systems is warranted. Current body armor research focuses on penetrating fragmentation protection from kinetic energy weapons. Several models have been validated against blunt injury trauma and penetrating trauma but have not been as extensively studied against primary blast wave effects. In addition, trauma injury scoring systems have focused on blunt injury trauma of body organs secondary to vehicular mishaps. Gross trauma from overpressure blast weapons has been demonstrated in gelatin, clay, animal and human surrogate models such as the Thoracic Cage and GelMan models. The parameters of a blast wave have not been correlated with the extent of damage from a cellular level with defined metrics such as chemical mediators, energy production, lysosomal release, cell wall destruction, ultrastructural damage and cellular dysfunction. New approaches are necessary in understanding the interaction of an enhanced blast munitions event with the human system based on the coupling effect of energy in relation to organ and tissue damage. It is anticipated that this effort will leverage existing technologies from research in the blast community in areas of blast wave propagation, impact characterization of body armor, organ/tissue impact effects and blast wave sensor detection.

PHASE I: To develop and demonstrate countermeasures to the primary blast of enhanced munitions, it is necessary to understand the effects on human physiology of the weapons and then use this understanding to design appropriate countermeasures. In the first Phase, proposers will conduct a feasibility study to establish an understanding of the effects of enhanced blast munitions on tissue/organ damage and test computational designs. Proposers will also develop preliminary approaches for external protection from the effect of the blast wave or internal protection against collapse and expansion of gas-filled organs after exposure to the blast wave. This Phase will include an elucidation of the specific requirements necessary for making realistic measurements in a closed room.

PHASE II: In this phase, proposers will measure trauma injury scores to blast effects of defined tissue/organs via animal and/or human surrogate models and compare these to the computational models used to assess tissue/organ damage. They will also demonstrate and quantify protective personnel countermeasure technologies in experiments to assess pulmonary, gastrointestinal and neurological damage. An analysis of tissue specimens will need to be correlated with damage mechanisms and blast loading features in correlation with blast computational models.

PHASE III DUAL USE APPLICATIONS: Any countermeasure technologies against primary blast effects will have use in law enforcement and building design. These future models will have a direct effect on designing body armor to minimize human injury against next generation enhanced blast weapons.

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KEYWORDS: Enhanced Blast Munitions, Tissue Surrogate Models, Computational Models, Body Armor, Trauma Injury Scores.

DARPA SB032-033 TITLE: Adaptive Structures Applications of Piezoelectric Single Crystals

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: Devise and fabricate practical devices for defense and civilian applications in the adaptive structures arena that exploit the extraordinary electromechanical properties (high coupling: 90-95 %; high strain: ~ 1 %) of single crystal relaxor piezoelectrics.

DESCRIPTION: Near the onset of 1997 came the discovery that single crystals of certain relaxor ferroelectric (lead magnesium niobate – lead titanate, and lead zinc niobate – lead titanate) materials exhibit extraordinary piezoelectric properties, namely, strains exceeding 1%, and electromechanical coupling exceeding 90% (compared to 0.1% and 70-75 %, respectively, in state-of-the-art piezoceramics) [See references below]. Concerted efforts to grow these materials in a variety of forms (bulk, multilayer, fibers, thin films, etc.) now yield materials in quantities, and at a price, suitable for device prototyping. Efforts to exploit these materials in Navy Sound Navigation & Ranging (SONAR) systems are already underway; this topic aims to exploit these enhanced electromechanical properties in practical devices in a different arena, namely, the adaptive control of structural shape and vibrations. For example: the high coupling leads to higher bandwidth and dramatically reduced demands on the electronics, while the high strain leads to higher actuation authority (more than an order of magnitude increase); actuators employing these materials are more efficient and compact; and sensors are smaller and more sensitive. While this topic is open to a broad range of applications, the proposed device should rely on the special properties of the relaxor piezocrystals. In describing the application, state what property of the crystals is being exploited and why this is essential to the success of the proposed application. A design—no matter how clever—that could be realized effectively with conventional materials is not responsive to the intent of this topic. An Army, Navy, or Air Force application specialist endorsing the importance of the enhanced performance in the proposed device would be a big plus.

PHASE I: Conceptually design, and demonstrate feasibility on a laboratory scale, a practical device exploiting high-strain, high-coupling relaxor piezocrystals in adaptive structures. Identify by cogent analysis explicitly how (size, weight, energy requirements, etc) this device exceeds what could have been done with conventional materials.

PHASE II: Refine the design and demonstrate—in a device as close to full scale as possible—the performance enhancements of the proposed device.

PHASE III DUAL USE APPLICATIONS: Applications in the defense sector range from Navy acoustic stealth, through Army rotorblade control, to Air Force airfoil shape control. In the civilian sector, applications extend to include active machine tool control and vibration suppression in HVAC systems.

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KEYWORDS: Electromechanical Sensors and Actuators, Smart Materials, Vibration Control, Shape Control, Adaptive Structures, Piezoelectrics, Single Crystals, Lead Magnesium Niobate –Lead Titanate, and Lead Zinc Niobate – Lead Titanate.

DARPA SB032-034 TITLE: Schema-Less Query Language for Relational Databases

TECHNOLOGY AREAS: Information Systems

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OBJECTIVE: Develop a query language relational database that does not require any knowledge of the database schema and develop corresponding methods for a relational database management system to automatically self-manage its own schema.

DESCRIPTION: Today's relational databases are too difficult to create, use, and modify. The specific limitations of current databases include:

- The schema of a database must be designed before data can be inserted
- Users and applications need to know the schema before querying the database
- Because queries refer schema, the SQL language is more complex than necessary
- Changes to the schema invalidate application interfaces and confuse users; thus, poorly designed schema are often retained despite their shortcomings
- Integrating existing databases are difficult because schema must first be understood and often re-engineered
- Creating new information systems based on databases are limited by the need for a prior data modeling; as a result, databases are under-utilized, and information sharing is ad hoc or manual method are retained in favor of automation

Clearly, many of the problems associated with current databases arise from exposing the internal database structure to users and applications. The basic approach implied by this topic is to abstract the schema and make it a responsibility of the relational database management system, thus creating future opportunities to reorganize and optimize the internal structure for performance. Users and application programs should not have to refer to table names or how to join them to answer complex queries or even to add information into the database---they should only have to know term names (column names) that are commonly agreed-upon. These enhancements will make databases cheap to create, maintain, and exploit. Together with discovery and term translation methods the same technology will facilitate integrating existing databases.

PHASE I: Conduct research and development to determine the scientific and commercial feasibility of designing a schema-less query language for relational databases such that users do not need to know anything about the schema design methods for automated schema management so that the relational database management system can handle the new schema-less query language.

PHASE II: Design, implement, test, and demonstrate a schema-less query language using an off-the-shelf relational database management system. Compare the performance of the new language with SQL and optimize the code to make it as competitive as necessary and feasible. If resources permit, develop algorithms for automatically re-structuring the database for performance based on query history.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in many, many commercial business applications. The market is broad, and the opportunity is great: among small businesses, relational databases are the least used major application despite the utility of structured information because the technology is too hard to use.

KEYWORDS: Relational Database, Query Language, Schema, Artificial Intelligence.

DARPA SB032-035 TITLE: Secure Programming Using Artificial Intelligence Techniques

TECHNOLOGY AREAS: Information Systems

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OBJECTIVE: Develop techniques that support the addition of artificial-intelligence (AI) techniques into application software while maintaining confidence that the techniques do not introduce security vulnerabilities into the software.

DESCRIPTION: Programming paradigms for AI techniques have included search strategies, rule-based systems, logic programming, object-oriented programming, etc. A number of tools are available to assist developers in adding AI techniques to their programs (e.g., CLIPS, MLC++, Epilog). Interestingly, there is substantial interest in the game programming community, where a number of focused tools (e.g., AI.Implant, Brainiac, DirectIA) exist to add intelligence to characters in games using standard AI techniques such as rule chaining, path finding, neural networks, fuzzy logic, genetic algorithms, etc).

Generally, addition of complex algorithms makes software harder to analyze, and introduces possible security vulnerabilities, e.g., in which programs can be tricked into executing operations for a remote attacker, in which programs can be tricked into divulging sensitive information, or in which low-level access may be given to an

attacker (e.g., via a buffer overflow).

PHASE I: This phase will analyze one, or a few mainstream AI toolkits, and characterize any security vulnerabilities discovered.

PHASE II: This phase will develop tools that work with mainstream AI toolkits to reduce the risk that use of the toolkits will result in security vulnerabilities. In the case that Phase I has found that there are minimal security vulnerabilities in the selected toolkits, this task will analyze that result and formulate techniques for generalizing it to other classes of software.

PHASE III DUAL USE APPLICATIONS: This technology could be used in a broad range of military and civilian applications where use of (AI) techniques confers significant benefits but where open interfaces and networking expose systems to security threats. For example, AI techniques may be used in network management systems, intrusion detection systems, situational awareness systems, logistics systems, and intelligent office assistants.

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KEYWORDS: Artificial Intelligence, Information Processing, Security, Software Development.

DARPA SB032-036 TITLE: MyDay Personal Data Capture System

TECHNOLOGY AREAS: Information Systems, Human Systems

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OBJECTIVE: Develop a very low cost wearable data capture system to support the "physical" data stream acquisition on a person as they experience their daily life. The physical data stream, as a minimum, includes visual, audio, and geolocation information.

DESCRIPTION: The minimal MyDay Personal Data Capture System version would include a tiny digital camera, microphone, inertial measurement sensors, compass, user interface, processor, several hundred megabytes of memory, Universal Serial Bus (USB) or Firewire interface, and a replaceable battery. Compact packaging is desired perhaps, a lapel pin or headband-mounted (usable with or without a hat) sensor head connected down to a base unit worn on the belt. Ultimately, the separate base unit should be incorporated into a single MyDay system. A global positioning system (GPS) and a better user interface are features that should be elements of an enhanced version. A mass-produced commercial product should sell for less than $200. This is NOT a "wearable computer" in the sense of providing computing resources to the user; it is a data acquisition system.

A minimal operational concept for the MyDay Personal Data Capture System is as follows. The user puts MyDay on in the morning and starts recording data. At the end of the day, the user uploads the data to a personal computer (PC) and recharges or replaces the battery. Data is recorded at high rate until the memory is full, then the lowest priority data is replaced with new data if the new data is higher priority. Therefore, frequent uploads to the PC after a couple of hours will provide more complete coverage as well as higher data fidelity than if it runs for 12 hours. The software uses the inertial sensors to avoid picture blur, and compares successive images to help decide what to throw away next. The unit listens for voice, especially the user's voice, and tries to capture complete conversations within privacy considerations. The audio algorithm may adjust capture rate resulting in good quality audio, when there is something interesting to hear and lower quality audio at other times. The user interface should provide inputs to enter personal preference concerning "level of interest", or "reset", or ask for "status", in which case the display or indicator lights show how full the memory is, how much battery is left, and so on. Creativity and innovation are highly encouraged.

PHASE I: (1) Conduct a feasibility analysis for the MyDay system using commercially available components and

evaluate the acquisition of at least 24 hours of "physical" data streams while worn by a person. The components can be configured using a modular architecture and not constrained by size, weight, and power limitations. The results of this analysis should be used as a baseline for the MyDay integrated design. (2) Prepare a design document for an integrated MyDay Personal Data Capture System. This should include complete specifications of all the system components and identification of sources, estimated costs, and algorithms for data management, storage, system monitoring, and configuration management.

PHASE II: Fabricate and demonstrate an integrated MyDay Personal Data Capture System prototype. Develop a test plan and collect 30 consecutive days of data for a single person. Document system integration, algorithm performance, and packing plans to miniaturize components and for commercial production for both basic and enhanced versions.

PHASE III DUAL USE APPLICATIONS: Fabricate the basic and expanded versions of the MyDay Personal Data Capture System. The technology developed under this SBIR can be used in the markets for personal digital assistants and electronic journals as well as navigation and daily living aides to the elderly and the visually impaired and disabled.

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KEYWORDS: Personal Digital Assistant, PDA, Digital Video, Handheld, Digital Audio, GPS, Pedestrian Navigation, Data Capture.

DARPA SB032-037 TITLE: Advisable Web Assistant for Extraction of Time-Critical Information

TECHNOLOGY AREAS: Information Systems

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OBJECTIVE: Design and implement a cognitive software assistant capable of (a) continuously monitoring networked information sources to discover, retrieve, and assess time-critical information according to a user's specification of interest; (b) extracting and condensing relevant features essential for decision making and alerting the user in the most appropriate manner to minimize impact on cognitive load; and (c) continuously improving its performance through self-learning and by accepting advice from the user.

DESCRIPTION: Information retrieval technology has improved substantially over the past several years through advances in search engines but challenges in timely discovery and distillation of time-critical data into actionable information remain. Recent research has explored the notions of a web assistant (e.g., [1]) that learns from observing user behavior to produce more effective and relevant searches and an assistant (e.g., [2]) that can learn by explicitly incorporating advice from the user to focus the search and extract salient details. This topic is concerned with significantly extending those capabilities to deal with time-critical information, such as news reports, business or market information, and real-time data acquired from sensors that must be discovered, evaluated for importance (particularly with regard to changes) and condensed into an actionable message sent to the user as an alert in the most appropriate manner depending on the current context of the user, possibly through one or more wireless communication methods (e.g., e-mail, text messaging, paging) for action within minutes or hours.

The key technical challenge in achieving this is developing a cognitive agent capable of acquiring and exploiting a sufficiently rich spectrum of advice to allow it to efficiently discover and evaluate critical information with high probability in time sufficient for action while minimizing false alarms. A second challenge is extracting salient information from information sources in a form useful for decision making. A third challenge is assessing the user's current context (location, activity, cognitive load) to determine the most appropriate alert mechanism, incorporating additional advice from the user on which mechanisms to use in which contexts. Finally the agent should be able to evaluate the effectiveness of advice, explain how the alerts were derived from the advice, and refine and improve its performance over time.

PHASE I: Define cognitive assistant architecture including basic approaches for advice taking, information extraction, user context assessment, and evaluation metrics for a chosen target domain. Demonstrate on simple definition of "advice" such as characterizing potentially important single information sources.

PHASE II: Full implementation and validation of effectiveness. Demonstrate on more complex definitions of "advice" that may involve correlation of multiple sources, time dependences, etc. Demonstrate ability to explain behavior and improve performance over time. Show feasibility of translating concepts to a second domain.

PHASE III DUAL USE APPLICATIONS: National security applications include intelligence analysis, situation awareness for command and control, and logistics. Potential commercial applications include financial market tracking, emergency response, and weather and traffic monitoring.

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KEYWORDS: Cognitive assistant, advice-taking, intelligent agent, information retrieval, information extraction, machine learning, cognitive load, time-critical decision making.

DARPA SB032-038 TITLE: Integrated System for Emotional State Recognition for the Enhancement of Human Performance and Detection of Criminal Intent

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Human Systems

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OBJECTIVE: Develop a non invasive emotion recognition system for the detection and categorization of the emotional/stress state of the subject. The system should be suitable for deployment in military/operational environments or in environments in which discrete observation of potential enemy threats is desired.

DESCRIPTION: Humans communicate both intentionally and unintentionally through a variety of emotional expressions. These expressions are most easily observed in the speech patterns, facial expressions, and body language of the individual. From these expressions we naturally draw inferences about an individual's hostile or friendly intent, or their level of stress, fatigue, or confusion. In many circumstances, however, it is difficult or impossible for human observers to make the necessary observations of another's emotional expressions and make reliable assessments of the individual's future actions or capabilities. The observer's own emotional or psychological states can affect such judgments, or the individual of interest may be in an operational environment that is not conducive to direct observation by others. In addition, there is information available on the emotional or stress state of the individual that has not yet been explored or exploited; examples of this include thermal imaging of the human face and body and detection of chemosignals (e.g. pheromones, volatile steroids).

Automated emotion detection systems could perform such assessments around the clock and free from personal bias. Such systems could be used to assess fitness for duty, integrated into closed loop systems regulating user vigilance and workload, or used to detect the sinister intent of individuals and prompt pre-emptive interdictions. These systems could unobtrusively monitor individuals within military operational environments or crowded civilian settings by relying on passive detection of the emotional aspects of speech, face, and gesture patterns and other novel measurements. The current effort would build upon existing technologies and incorporate novel remote sensing technologies to develop systems capable of detecting, categorizing, and responding to the emotional information encoded in human speech, facial expressions, gestures and other emitted signals. Key emotional/cognitive states detected should include, but need not be limited to, anger, drowsiness, anxiety, fear, confusion, disorientation, and frustration. The necessary systems must be capable of functioning in crowded civilian and/or military/operational environments characterized by high background noise and multiple speech sources and should be sufficiently rugged, light weight, and unobtrusive to function in military/operational environments.

PHASE I: Conduct an exploratory study to characterize and describe the emotional states that will be detected. Determine the feasibility of an emotional state recognition system that incorporates at least two of the following: speech, facial expression, gesture and one additional sensor to detect novel biometrics like chemosignals (pheromones, volatile steroids) or thermal imaging.

PHASE II: Design and develop a prototype integrated emotional state recognition system for testing in a realistic environment. Prototypes should not merely assess, but give a categorization as to the state of the user. Conduct testing under varying stress conditions and operational demands.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian applications where automatic real-time detection of cognitive, emotional, or stress state would permit assessment of and proactive interdiction to improve worker fitness for duty – for example, in long-duration flight operations or in managing vigilance for air-traffic controllers.

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KEYWORDS: Emotion, Stress, Cognitive State, Speech, Gesture, Facial Expression, Chemosignals, Thermal Imaging, Pattern Detection.

DARPA SB032-039 TITLE: Ultra-Compact, High Range-Resolution LADAR for the Individual Soldier

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: Develop ultra-compact laser radar (LADAR) that can produce high resolution images (both range and intensity) over short distances (tenths of a kilometer) and that is small enough and power-efficient enough to be carried by an individual dismounted soldier.

DESCRIPTION: Range imagery is finding increasing use in airborne targeting applications as well as reconnaissance and surveillance from ground vehicles. These applications are proving the value of extracting 3D target profiles registered with intensity images to improve target acquisition and recognition performance, especially for partially obscured and camouflaged targets. While there is progress in extracting range and 3D information from passive imagery, laser radars with active illumination are the preferred range-imaging technology of choice today. However, today's LADARs typically provide either course resolution, slow image formation times, or very narrow fields of view, but work effectively at standoff ranges of kilometers to tens of kilometers. Technical innovations are required in LADAR design and fabrication that would provide the benefits of high resolution range imagery to the individual dismounted soldier. For the dismounted combatant, a LADAR would need to be very small, light weight, and power efficient, for example on the order of one-half kilo or less and require less than 0.5 watts of power averaged (assuming the soldier would activate his LADAR less than 5% of the time). Bistatic sensor solutions, for example with the illuminator on the soldier's rifle and the detector on his helmet, if technically feasible, would be especially attractive. The LADAR would need to work over ranges of tens to a few hundreds of meters and provide reasonable spatial resolution, for example 320X240 as a minimum. The LADAR would need a field of view ideally on the order of 40 degrees or better or alternatively a way to stitch together multiple, manually scanned range images, each with a much narrower field of view. Range resolution would need to be on the order of ten centimeters or better. Because the soldier can be constantly moving in complex ways and the angular rate of change is high for objects close to the soldier, innovative approaches are needed for achieving very short acquisition times, for example flash LADAR with very short bursts of illumination. Technical innovations to minimize the LADAR's signature and time of exposure are critical as well because active illumination can disclose a soldier's location.

PHASE I: Conduct a feasibility study complete with supporting analysis and design trades exploring the potential performance and feasibility of a small, light weight, high resolution; low power LADAR that produces range and intensity images and that is capable of being carried and used by an individual dismounted soldier.

PHASE II: Design, fabricate and demonstrate a bench-top version of the LADAR. Provide experimental data showing how the test bed version meets range and resolution requirements. Provide supporting analysis showing how the bench-top demonstration provides the basis for a full prototype in a soldier-mounted form factor, including a weight and power analysis. Provide a production-cost analysis estimating the production cost of units based on this design when manufactured in volume.

PHASE III DUAL USE APPLICATIONS: LADAR sensors are seeing increasing use in the commercial and civil government sector in applications ranging from collision avoidance for vehicles, to robotic guidance, to 3D urban mapping, to 3D environmental analysis for flood and aerosol dispersion projections. In the commercial domain, a small, man-portable LADAR capable of producing high resolution range images would allow individual real-time 3D modeling and simulation for applications in real-estate, construction, collaborative visualization, and virtual-reality based entertainment. Military uses include target acquisition and recognition, threat detection in urban combat, and 3D mapping of complex micro-terrains to support mission planning, rehearsal, simulation and training.

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2. A. Jelalian, "Laser Radar Systems," Artech House, Boston, 1992.

KEYWORDS: LADAR, Range Imagery, Micro-LADAR, 3-D Imaging, Laser Radar, LIDAR, Laser Scanners, Flash LADAR.

DARPA SB032-040 TITLE: Novel Airborne Video Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: Develop new motion-imagery sensors that are specifically designed for use on board low-altitude aircraft performing reconnaissance missions in difficult terrain.

DESCRIPTION: Military operations in urban and jungle environments place extraordinary demands on sensing systems for situation assessment, reconnaissance, surveillance, targeting, and damage assessment of sites, vehicles, and military troops. In response to this emerging requirement, DARPA and other organizations are developing various aerial sensor platforms that can be applied to close-in sensing of urban and jungle operations. The aerial robots include rotorcraft such as the DARPA Organic Air Vehicle and fixed wing micro aerial vehicles (www.darpa.mil, Tactical Technology Office, Unmanned Systems Programs). These vehicles will operate at altitudes well under 1,000' above ground level and will soon be capable of maneuvering through forests, through city streets and possibly even through doorways. While the mobility, power, communications, and flight control issues are rapidly being worked out, the sensors and sensor interpretation algorithms for the payloads are largely limited to those already developed for other applications. The intent of this SBIR topic is to challenge industry and academia to devise new sensors that are tailored specifically for mission's on-board small airborne platforms working at low-altitude in difficult terrain, and possibly low lighting conditions.

Conventional video sensors employed on manned and unmanned aircraft are limited by many factors, including resolution, field of view, color bands, polarization, dynamic range, signal-noise ratio, depth of focus, frame-rate, atmospheric attenuation, low light levels, and line of sight. As such, they may not be optimal for any given mission or scenario. Because digital video technology has been advancing rapidly, DARPA believes that there is an opportunity to overcome some of the limitations of conventional sensors by exploiting emerging digital imaging and image processing techniques. As one example, a sensor with multiple Charge-Coupled Device (CCD) arrays can be operated in modes that variously improve the field of view, resolution or frame-rate according to the current demands of the image acquisition scenario. However, the added flexibility must be accomplished in a form-factor consistent with the size, power, weight, and cost considerations of small, unmanned air vehicles.

Prospective developers should conduct a feasibility analysis of a specific concept. The successful proposer must clearly specify the target application and the envisioned sensor concept. The analysis shall include discussion of how the proposed sensor will overcome the limits of conventional sensors to meet the demands of the target application, and a comparison of the value-added with respect to existing or simpler solutions.

PHASE I: Evaluate the feasibility of their proposed concept using any combination of techniques such as analytical modeling and simulation, or breadboard laboratory experiments using available hardware and software. The evaluation should clearly show that the concept is capable of detecting, recognizing/classifying, modeling, locating or tracking the targets of interest, under a range of environmental conditions.

PHASE II: Conduct a proof-of-principle by developing a brass board sensor system and demonstrating its operation during a set of field experiments against live targets in a real environment.

PHASE III DUAL USE APPLICATIONS: The sensors and sensor concepts developed under this SBIR are also applicable to commercial surveillance systems used for physical security, law enforcement, market research, and planetary exploration.

REFERENCES:
1. The Journal of Electronic Imaging, Jan P. Allebach, editor, The International Society for Optical Engineering, http://www.imaging.org/pubs/jei/index.cfm.

KEYWORDS: Electro-Optic Sensors, Digital Video, Airborne Surveillance, Motion Imagery, Micro Air Vehicles, Image Understanding.

DARPA SB032-041 TITLE: Bistatic Target and Clutter Characterization for ISR Radar Systems

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

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OBJECTIVE: Develop an understanding of bistatic clutter and target signatures to support performance predictions for bistatic and monostatic / bistatic Intelligence, Surveillance, and Reconnaissance (military) (ISR) radar systems.

DESCRIPTION: While the ISR community has spent a substantial effort understanding monostatic clutter and target signatures in programs like DARPA's Semi-Automated IMINT Processing (SAIP), Moving and Stationary Target Acquisition and Recognition (MSTAR), and RADIUS Common Development Environment (RCDE), little investment has been made to understand bistatic signatures relevant to tactical applications. Civilian remote sensing applications, most notably Digital Terrain Elevation Data (DTED), have led to clutter decorrelation studies, the results of which now substantially influence sensor and post-processor design decisions [1,2]. It is well recognized that bistatic systems offer advantages of spatial diversity and some level of covertness not offered by monostatic systems. Although there are ongoing bistatic system studies, emphasis to date has been on geolocation and kinematic tracking. The role of signature phenomenology is well recognized in monostatic programs and should be extended to bistatic system concepts.

There are several issues that need to be addressed. Long baseline change-based moving target indicator (MTI) systems utilizing monostatic and bistatic returns rely on the equivalence of monostatic and bistatic clutter returns. Under certain well defined conditions the monostatic-bistatic equivalence theorem can be applied and good clutter cancellation can be achieved [3]. To the extent that these conditions are not met, clutter cancellation will suffer and target detectability degrades. For targets, it is well understood that certain scattering centers will satisfy the equivalence theorem (e.g. low gain ~ point scatterer) while others (e.g. corner reflectors) will not. To the extent that the theorem holds, monostatic signatures can be used to predict bistatic signatures. To the extent that the theorem is violated, the bistatic measurement represents innovation, information that could possibly used to classify a specific scattering center or even the target. In addition, large variations in monostatic and bistatic target signatures can adversely affect geolocation systems due to the combined effects of target glint and geometric dilution of precision. To the extent these differences can be characterized, the performance of long-baseline systems can be predicted and could influence both design and operational decisions related to this class of system.

PHASE I: Conduct a feasibility study to understand monostatic / bistatic equivalence issues utilizing existing tools and datasets. Characterize findings and implications for change-based MTI clutter cancellation and target identification. Identify deficiencies in existing tools and datasets. Propose tool enhancements, data collections and analysis for Phase II.

PHASE II: Enhance understanding of bistatic signatures through the design, execution and analysis of additional measurements using existing measurement assets and improved tools for bistatic signature analysis. Develop models for bistatic target signatures and clutter. Develop performance predictions for candidate bistatic systems using models developed.

PHASE III: DUAL USE APPLICATIONS: Digital mapping techniques with both military and civilian application for the military should benefit from this work. Design of military and civilian remote sensing systems should benefit from this work. Civilian remote sensing applications that rely on radar-based change detection, for agriculture, forest management and other environmental studies, will also benefit from this work.

REFERENCES:
1. H. Zebker et. al., "Decorrelation in Interferometric Radar Echos", IEEE Transactions on Geoscience and Remote Sensing, September 1992.
2. F. Gatelli et al., "The Wavenumber Shift in SAR Interferometry", IEEE Transactions on Geoscience and Remote Sensing, July 1994.
3. R. Kell, "On the Derivation of Bistatic RCS from Monostatic Measurements", Proceedings of the IEEE, August 1965.

KEYWORDS: Bistatics, Automatic Target Recognition, ATR, Semi Automated Target Recognition, Target ID,

Geolocation, Tracking, Multi-Lateration, Targeting, Interferometer, Interferometry.

DARPA SB032-042 TITLE: Wearable Sparse-Conformal-Acoustic-Networks for Tracking & ID of Urban Targets

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: Design and demonstrate an inexpensive wearable Sparse Conformal Acoustic Networks (SCAN) to detect, localize, acoustically fingerprint, track, and categorize urban acoustic signatures as noncombatants, combatants, friend, or foe.

DESCRIPTION: A capability is needed to help "boots on ground" operate more effectively in the chaos of the urban battlefield. A key requirement is improved real-time situation awareness to avoid ambush, unintentional civilian casualties and friendly fire tragedies. One solution is Sparse Conformal Acoustic Networks (SCAN) or soldier-worn acoustic array "vests". SCAN-equipped soldiers are essentially mobile ground sensors. When coupled together by 60 GHz communications, a squad of SCAN-equipped soldiers entering a building is transformed into a mobile human acoustic array capable of detecting, localizing, and categorizing low detectable acoustic signatures as noncombatants, combatants, friend, or foe using "voice recognition"-like algorithm technologies generalized for "acoustic signature recognition".

This effort will develop and demonstrate a prototype wearable Sparse Conformal Acoustic Network based on low cost dual-mode (active/passive) acoustic sensors, advanced acoustic processing and recognition algorithms, and 60 GHz short range low power communications. Small affordable dual-mode acoustic sensors actively probe and model the urban noise field to greatly improve weak-signal detection. Advanced acoustic imaging and aided target recognition (ATR) algorithms process and ID weak target signatures buried in strong urban noise. The 60 GHz communications technology allows for wideband low probability of intercept operation. This unique combination of advanced system technologies will produce a level of detection, localization, and ID performance against noncombatant and combatants in urban environments that is unachievable to date.

PHASE I: Identify principle technology challenges. Develop a preliminary system design that defines the sensor, processing, communications, and exploitation requirements. Demonstrate a single node (a single soldier) dual-mode SCAN of a human combatant moving through an urban noise field using computed aided designs.

PHASE II: Show the scalability and robustness of SCAN concept. Design, develop, and demonstrate a deployable 4-node SCAN operating against a large acoustic target set within a complex urban noise field. Through simulations, demonstrate scalability to an 8-node capability (an 8 person SCAN equipped squad) for improved performance.

PHASE III DUAL USE APPLICATIONS: This system could be used to develop conformal ultrasound imaging technology for improved medical imaging and industrial NDE (nondestructive examination).

REFERENCES:
1. T.D. Abhayapala and D.B. Ward, "Theory and design of high order sound field microphones using spherical microphone array", IEEE Int. Conf. Acoust., Speech, Signal Processing (ICASSP-2002), vol. II, pp.1949-1952, Orlando, FL, USA, May 2002.
2. M.S. Brandstein and D.B. Ward, Eds., "Microphone Arrays: Signal Processing Techniques and Applications", Springer-Verlag, Berlin, 2001.
3. D.B. Ward, "Joint least squares optimization for robust acoustic crosstalk cancellation"', IEEE Trans. Speech Audio Processing, vol. 8, no. 2, pp.211-215, Mar. 2000.
4. M. S. Brandstein and H. F. Silverman, "A Robust Method for Speech Signal Time-Delay Estimation in Reverberant Rooms", Proceedings of ICASSP-1997, Munich, Germany, April 1997.
5. T. Pham and B. Sadler, "Wideband acoustic array processing to detect and track ground vehicles," 1st Annual ARL Sensors and Electron Devices Symposium, pp. 151-154, College Park, MD, January 1997.
6. J. L. Flanagan and E. E. Jan, "Sound Capture form Spatial Volumes: Matched-Filter Processing of Microphone Arrays Having Randomly-Distributed Sensors", Proceedings of ICASSP 96.

KEYWORDS: Urban Warfare, Acoustic Surveillance, Array Processing, Pattern Recognition.

DARPA SB032-043 TITLE: Hierarchical CAD Tools for Radiation Hardened Mixed Signal Electronic Circuits

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

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OBJECTIVE: Development and demonstration of Computer Aided Design (CAD) tools for automated design of radiation hardened mixed signal electronic circuits. These tools should enable the capability to design circuits that are better protected against the deleterious effects of total ionization dose (TID), single event effects (SEE) and prompt dose.

DESCRIPTION: A critical bottleneck for the designer of mixed signal microelectronics exposed to space radiation, is that estimating the system wide performance is practically ad hoc, or empirically based and very time consuming. Innovative research is needed for the development and verification of tools that will migrate circuits designed into older processes/technologies that function within the strategic radiation hardness level, over to technologies/processes that are current in the industry. Scaling of electronic circuits into the deep sub-micron (DSM) range has made systems more vulnerable to device/system upsets caused by radiation while also increasing the time to migrate radiation-hard designs to commercial processes. Although the current empirical approach has been successful in producing rad-hard circuits, it is becoming increasing difficult to keep pace with technology scaling.

Hierarchical CAD tools offer the potential to significantly improve the ability to design radiation-hardened circuits into current/commercial technologies and processes. The development of automated tools will greatly simplify the production of net lists with detailed information on photocurrent migration and highlight nodes that are most susceptible to photocurrent damage. Critical areas of CAD tool development will involve (1) behavioral circuit simulators supported by device physics, (2) automated extraction of space and electromagnetic interference (EMI) parasitic effects, (3) synthesis algorithms, which predict optimal tradeoffs (between performance and hardness variables), achievable over the span of radiation aware design space (e.g. mixed signal radiation hardened cell libraries and technology files) and (4) automated layout tools, that are aware of, and mitigate the radiation, electromagnetic (EM) and thermal parasitics. Such tools will enable high performance layout, sizing, routing of interconnect, bus, clock and power lines that are optimized against strategic/natural space radiation and EMI.

DARPA is interested in exploring the feasibility of developing a new generation of CAD tools and libraries to enable the design of integrated rad-hard mixed signal electronic circuits. The integrated CAD capability will incorporate (1) a novel “flow up” paradigm, where parameters, such as current leakage, doping profiles, charge trapping, fluence, (linear energy transfer) LET, carrier transport, etc, will flow up, from device and compact models into a behavioral circuit simulator and synthesis backbone, (2) synthesis design tools to perform system wide radiation and electromagnetic interference trade-off analysis.

PHASE I: Conduct a feasibility study to describe and characterize the performance of devices and mixed signal circuits under various radiation conditions, i.e., analyze and assess opportunities for mitigating not only TID, but SEE and prompt dose effects on mixed signal integrated circuit (IC) performance. Demonstrate feasibility of using models to migrate designs between different technologies/processes quickly and efficiently. Develop fast parasitic extraction of SEE, TID and prompt dose effects and demonstrate parasitic aware routing, placement and layout tools. The Phase I effort will also develop a plan to interface tools with either new or existing design environments in order to validate and demonstrate the methodology in Phase II.

PHASE II: Develop models to demonstrate the automated synthesis, verification and optimization of rad-hard circuit architectures. Demonstrate the ability to predict optimal tradeoffs (between performance and hardness variables), achievable over the span of radiation aware design space. Develop and implement radiation hardened model libraries for components and sub-blocks/circuits based on coupled electrical/radiation performance characteristics. The Phase II effort will also implement the plan (developed in Phase I) to interface the radiation

hardened CAD tools with design environments for electronic circuits. Performance verification and validation studies will be completed (on a military relevant mixed signal circuit) to demonstrate the capabilities of the design tools. Complete documentation of the radiation-hardened design methodologies, test cases and the test results must be delivered upon completion of the contract.

PHASE III DUAL USE APPLICATIONS: This effort will form the groundwork for advanced CAD tools for routine analysis and design of a new generation of integrated radiation hardened mixed signal electronic circuits with superior immunity to SEE, TID and prompt dose. This will have a significant impact on the design of high performance sensing, communication and processing systems for current and future military requirements, both in space and in airborne avionics. It will also impact commercial applications where the sensitivity of electronic circuitry to terrestrial alpha and neutron bombardment causes damage worth several millions of dollars each year.

REFERENCES:
1. Buchner, S., and Baze, M., "Single-Event Transients in Fast Circuits", 2001 IEEE Nuclear and Space Radiation Effects Conference, pp: V-1 to V-105, 2001.
2. Dodd, P., “Basic Mechanisms for Single-Event Effects”, 1999 IEEE Nuclear and Space Radiation Effects Conference, pp: II-1 to II-85, 1999.
3. Tausch, H.J., Alexander, D., “Radiation Effects Testing of Mixed Signal Microcircuits”, 2000 IEEE Nuclear and Space Radiation Effects Conference, pp: V-1 to V-47, 2000.
4. Schwank, J., “Total Dose Effects in MOS Devices”, 2002 IEEE Nuclear and Space Radiation Effects Conference, pp: IV-1 to IV-123, 2002.
5. Weatherford, T., “From Carriers to Contacts: A Review of SEE Charge Collection Processes In Devices", 2002 IEEE Nuclear and Space Radiation Effects Conference, pp: IV-1 to IV-105, 2002.

KEYWORDS: Exo-Atmospheric Battlespace, Radiation Hardening, Single Event Effects, Total Ionization Dose, Prompt Dose, Design Migration, Mixed Signal Circuits, Models and Libraries, Computer-Aided Design.

DARPA SB032-044 TITLE: Wide Bandgap Semiconductor Materials and Devices

TECHNOLOGY AREAS: Air Platform, Chemical/Bio Defense, Sensors, Electronics, Battlespace, Weapons

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OBJECTIVE: The objective of this program is to advance the state-of-the art of wide bandgap semiconductors by investigating novel materials, growth techniques, fabrication processes, and device concepts that will enable the demonstration of Wide Bandgap Semiconductors (WBG)-based components and Microsystems for future military and commercial applications.

DESCRIPTION: DoD systems are critically dependent on high frequency electronic sensors, high sensitivity optical detectors and imagers, and high efficiency power distribution and conversion systems. Wide bandgap semiconductors, namely silicon carbide (SiC) and gallium nitride (GaN), have unique properties that enable a leap-ahead capability in these areas enabling the performance of many future military systems. The technologies required for these sensors and systems have significant commonality across the DoD to enhance an effective transformation across the board. Recent progress in WBG semiconductor concept demonstrations, and evolving platform requirements, has resulted in WBG integrated circuit technology being identified as a key enabler for many DoD systems.

The activities under this effort will accelerate the development of WBG semiconductor materials, devices, and component technologies to reduce the technical risk and expedite military system demonstrations and insertions.

PHASE I: In Phase I, the programs should be focused in a feasibility study for the demonstration of the growth technique, materials, and fabrication processes. In some cases, in order to assess the feasibility of the growth process or techniques under investigation, fabrication of simple devices maybe required.

PHASE II: In the Phase II program, performers will optimize their concepts or techniques. The performers will validate their optimize processes with devices or materials that are suitable for the fabrication of state-of-the art

components. In addition, it is anticipated that the Phase II effort will culminate in scale-up processes that will meet the minimum entry-demands of the emerging industry.

PHASE III DUAL USE APPLICATIONS: It is anticipated that the commercial demand for wide bandgap devices, and components will increase exponentially during this decade, with a market forecast exceeding $5 billion dollars in sales by the year 2010 [2]. Many of these commercial opportunities will be created as a result of advances in WBG materials and devices. The three main commercial-application areas are: (a) energy, power control, and power distribution, (b) photonics and optical systems in applications such as, traffic control, large-area full-color displays, automotive, medical, illumination, consumer electronics, and data storage devices, and (c) wireless communications systems.

Even though our main interest is in pursuing more demanding requirements for DoD systems, the leverage that we can get from these commercial applications will provide the DoD with the economies of scale required for affordable military systems.

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1. E. Martinez "The Transforming MMIC" 2002 Proceedings GaAs IC Symposium, p. 7, Oct. 2002, http://ieeexplore.ieee.org/xpl/tocresult.jsp?isNumber=22472.
2. Semiconductor Industry Association, "Semiconductor Forecast Summary", June 2002, http://www.semichips.org/downloads/Summary.pdf.

KEYWORDS: Wide Bandgap Semiconductor Materials, Silicon Carbide, Gallium Nitride.

DARPA SB032-045 TITLE: Maskless Lithography for Fabrication of Microelectronics with 100 nm Features

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

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OBJECTIVE: Develop a tool allowing fabrication of advanced semiconductor devices without the need for masks, thereby avoiding the high front-end, fixed costs associated with photomask fabrication.

DESCRIPTION: The continuing increase in performance in microelectronics is made possible by the steadily decreasing size of transistors, summarized in the popular press as Moore's law. The key contributor to this improvement has been the lithography process which defines the intricate structures of the silicon chip. In the past, these small features were defined by projecting a pattern through a photomask onto the semiconductor wafer. Current manufacturing produces features shorter than the wavelength of the exposing light, at the expense of process robustness and complex mask structures. The maskless approach bypasses the requirements for the mask, giving up production rates while dramatically reducing the up-front fixed costs; this approach is particularly suited for low production rates (e.g. tens of wafers) such as needed for many military sytems and application specific integrated circuits (ASICs). The basic requirement for a maskless tool is a throughput of at least one wafer (200 mm dia.) per hour with features of 100 nm and below. Overlay accuracy and dimensional control are to be compatible with the usual conventional semiconductor manufacturing requirements applicable to a given feature size. Exposing beams may be photons or charged particles.

PHASE I: Define component approach and architecture. Identify key subcomponents (beam switching). Evaluate approach for throughput, feature size, overlay, and dimensional control.

PHASE II: Provide a detailed design for a complete system meeting the above requirements. Fabricate a minimum assembly, and demonstrate feature size, overlay, dimensional control, and scalability for throughput of one wafer level per hour.

PHASE III DUAL USE APPLICATIONS: The technology developed will apply to integrated circuit designs having the relatively low production volumes of military systems Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR), ASICs, and the initial engineering lots developed for high

volume commercial markets.

REFERENCES:
1. http://www.sematech.org/public/resources/litho/ngl/maskless0801/output.htm.

KEYWORDS: Lithography, Maskless Lithography, Direct-Write, Semiconductor Fabrication.

DARPA SB032-046 TITLE: Adaptive Self-Monitoring of Widely-Tunable WDM Transmitter

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

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OBJECTIVE: Design and implement intra-module sensing elements and adaptive self-monitoring algorithms to ensure tunable Wavelength Division Multiplexed (WDM) transmitter performance characteristics (e.g. wavelength, power, noise, etc.) under harsh environments.

DESCRIPTION: Advanced battlespace platforms require the interconnection of a large number of sensors (radar and others), data processors, and data storage equipment. These pieces of equipment communicate at high speeds (multi GHz) exchanging both analog and digital signals. Dynamic WDM networks offer a strong solution for these communication needs. In a dynamic WDM network, wavelengths are allocated to carry specific signals, adapting continuously to the information traffic conditions and the status of each piece of equipment. This continuous adaptation to the environment makes this type of network highly efficient and capable of high survivability. A key aspect of the implementation of such a network is the ability of each network element to intelligently monitor and adjust its own performance, to ensure optimum operation as well as communicate this information to appropriate monitoring hardware. Traditional characteristics such as power and wavelength must be maintained to a high degree of accuracy. In addition, transmitter noise level, spectral purity, and other characteristics can be sensed through either internal techniques or monolithic or micro-optic integration of the appropriate sensor within the transmitter package, allowing for a further degree of performance visibility, feedback control, and robustness. Intelligent monitoring of transmitter output noise, for example, can provide optimum analog RF performance throughout the life of the transmitter (RIN < -160 dB/Hz for >20 years). Further outgrowths of this technology include the ability for module self-calibration in the field, eliminating the need for a connection to dedicated, bulky laboratory instruments, and automatic link optimization.

PHASE I: Define performance and stability requirements, develop sensing concepts and algorithms, and demonstrate feasibility of achieving these through modeling or bench-top experiments.

PHASE II: Develop sensing elements suitable for hybrid or monolithic integration. Build transmitter prototypes incorporating laser, modulator, integrated sensing elements, electronics, and firmware implementation of algorithms, and provide DARPA (or its designate) with three prototype packaged transmitters.

PHASE III DUAL USE APPLICATIONS: Tunable lasers are finding significant applications in WDM networks. These devices provide increased flexibility to communication networks, improving their capacity, survivability, and cost of operation. These attributes make tunable lasers a key component for both defense and commercial applications.

REFERENCES:
1. "Control of Widely Tunable SSG-DBR Lasers for Dense Wavelength Division Multiplexing"; G. Sarlet et. al.; IEEE J. of Lightwave Technology, v.18, No.8, pp.1128-1138; August 2000.
2. "Frequency Plan and Wavelength Switching Limits for Widely Tunable Semiconductor Transmitters; R. O'Dowd et. al.; IEEE J. on Selected Topics in Quantum Electronics, v.7, No.2, pp.259-269; March / April 2001.
3. "Mode Control of Widely-Tunable SG-DBR Lasers"; M.C. Larson et. al.; Proceedings of European Conference on Optical Communication (ECOC); September 2002.

KEYWORDS: Tunable Laser, RF Photonics, Wavelength Division Multiplexing, WDM, Fiber-Optic Networks, Adaptive Control.

DARPA SB032-047 TITLE: Biological Degradation of Chemical Agents

TECHNOLOGY AREAS: Chemical/Bio Defense, Nuclear Technology

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OBJECTIVE: Develop a stable compact formulation of bacteria that degrade chemical warfare agents.

DESCRIPTION: There is a real possibility that US troops will encounter chemical warfare agent stockpiles in the War on Terrorism. Available methods for destroying these stockpiles would require extensive support technology such as incinerators or water reactors. This effort aims to develop a simple, self-sustaining system of natural or genetically modified bacteria that is capable of metabolizing chemical warfare agents and reducing their toxicity to safe levels. The goal is to develop an easily fieldable, ready to use formulation containing the bacteria and the nutrients needed for initial culture that can then be self-sustained during remediation. The "starter mix" of bacteria and media can potentially be lyophilized or compressed to achieve long term stability.

Performance tasks include: Demonstrate degradation of low volatility chemical agents such as VX, determine time for degradation, and demonstrate stability of the dried material in harsh environments.

PHASE I: Demonstrate degradation of low volatility chemical agents in laboratory testing. Evaluate lyophilization or other drying method to stabilize the bacteria.

PHASE II: Produce the stabilized bacteria and media formulations and test them for stability in harsh environments, ability to degrade low volatility chemical warfare agents on a 55-gallon scale, and degradation efficiency.

PHASE III DUAL USE APPLICATIONS: This technology has military implications for destruction of chemical warfare agents. This technology has potential application in remediation of chemical pollution.

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1. Biodegradation of gasoline by gellan gum-encapsulated bacterial cells. Moslemy P, Neufeld RJ, Guiot SR. Biotechnol Bioeng 2002 Oct 80:175-84, http://www3.interscience.wiley.com/cgi-bin/issuetoc?ID=97519507.
2. Reduction of perchlorate and nitrate by salt tolerant bacteria. Okeke BC, Giblin T, Frankenberger WT. Environ Pollut 2002 118:357-63, http://www.sciencedirect.com/science/journal/02697491.

KEYWORDS: Bacteria, Chemical Warfare Agents, Toxicity, Chemical Pollution.

DARPA SB032-048 TITLE: Unconventional Space Power

TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: Develop innovative and effective new power systems capable of supporting large peak loads and which significantly exceed current and projected specific energy densities of photovoltaic/battery systems.

DESCRIPTION: Conventional space power systems involving photovoltaics (PV) and batteries have evolved over the last five decades with increasing efficiencies and specific energies. Solar cell technologies have steadily improved in efficiencies approaching 35% and batteries have improved in specific energies to over 130 watt-hr/kg. Satellite electrical power management and distribution systems have evolved to higher voltages (100+VDC) busses resulting in less resistive losses and therefore more overall efficient designs. However, because PV/battery systems capture and convert only a narrow band of the sun's energy, they are reaching optimal design limits where their mass fraction of the total satellite and the launch packaging volume is excessive for single launched satellites requiring high power. Examples of such high power satellites include DoD concepts for large RF apertures, Directed Energy Weapons, space-to-space power transfers and high performance electric propulsion. These concepts can require an orbital average power exceeding 30Kw coupled with periodic high peak power demands for

limited duration. These future designs pose severe system performance challenges for current and projected PV/battery based space power systems.

DARPA/SPO is interested in advanced unconventional spacecraft power system concepts. Such systems include but are not limited to Electro-dynamic tethers, fuel cells, thermodynamic engines, advanced capacitors, radioisotope electric generators, flywheels, solar thermal, etc. Power technology systems of interest are those that can supplement PV/battery systems or operate on their own to meet high orbital average power requirements coupled with peak power demands for multiple periods during the spacecraft life-time. These unconventional satellite power systems should exceed the overall maximum specific energy densities of projected PV/battery systems and be durable to the space environment.

PHASE I: Identify promising unconventional power systems capable of supporting large peak loads and which significantly exceed current and projected specific energy densities of photovoltaic/battery systems. Develop conceptual designs and conduct Phase I analyses aimed at predicting potential performance gains and development costs.

PHASE II: Conduct detailed critical design analyses, computer aided modeling/simulation, and if appropriate, develop prototype systems/subsystems. Develop where appropriate, both ground and/or space-based test plans for risk reduction including methods of launching demonstration payload(s) (e.g., secondary, piggyback, etc.).

PHASE III DUAL USE APPLICATIONS: The continuing trend of commercialization of space affords an ideal opportunity to leverage novel space power investments for DOD applications to a multitude of potential civilian applications in satellite communications, imaging and remote sensing.

KEYWORDS: Space, Photovoltaic, Battery, Electrodynamic Tethers, Flywheels, Fuel Cells, Thermodynamic Engines, Advanced Capacitors, Radioisotope Electric Generators, Solar Thermal.

DARPA SB032-049 TITLE: Poly-Dicyclopentadiene Applications and Manufacturing Processes

TECHNOLOGY AREAS: Materials/Processes

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OBJECTIVE: Develop applications and manufacturing processes that take advantage of superior properties of poly-dicyclopentadiene (poly-DCPD) material.

DESCRIPTION: A unique system for polymerizing dicyclopentadiene monomer into a robust polymer suitable for many aerospace and transportation applications has been developed. This polymer has many excellent properties, including:

- Strength – high tensile strength even when unreinforced.
- High impact strength and toughness – demonstrated at 10 to 100 times better than epoxy based composites.
- Corrosion resistance – highly resistant to corrosive chemicals. Has been demonstrated for storage of caustic chlorine, hydrofluoric acid, and liquid fluorine.
- Simple surface treatment – the surface can be readily halogenated to reduce permeability and increase corrosion resistance.
- Low monomer viscosity – similar to water (measured at 5 centipoises), reducing void and bubble formation as well as enhancing surface adhesion and mixability in the formation of composites. Low viscosity also allows us to tailor the viscosity by adding thickeners.
- Low-cost and good availability – the supply of this monomer is huge because it is a byproduct of several industrial chemical processes and is readily available, low-grade monomer can be purchased for about 50 cents/lb and high grade monomer can be purchased for about twice this much.
- Low outgassing – properly treated, parts contain very small quantities of non-polymerized volatiles that can boil off in vacuum or high temperature environments.
- Machineable – polymerized parts machine as readily as aluminum using conventional machine tools.

Early work into aerospace and transportation applications of poly-DCPD indicated that it has similar properties to

epoxies for the same applications. Most importantly, poly-DCPD showed that it was two orders of magnitude greater mechanical toughness over epoxies. At cryogenic temperatures, when epoxies lose the majority of their strength and toughness, poly-DCPD retains its mechanical toughness. Poly-DCPD appears to offer physical property advantages for cryogenic applications. In addition to the excellent physical properties of the material, the extremely low viscosity of the formulation precludes many of the problems found in manufacturing with high viscosity (e.g. paste like) epoxies, eliminating voids and unfilled areas in the tank matrix. Poly-DCPD formulations do not require the use of autoclaves in order to achieve a proper cure. This alone presents a significant opportunity for cost reduction in the manufacture of composite parts. Many non-tradition manufacturing approaches are possible. This new material holds great promise for aerospace and transportation applications. The manufacturing processes and application formulations need only be developed.

PHASE I: The small business will identify and specify an application. The technical requirements from this application upon poly-DCPD will be determined. A possible formulation of, or formulations, of poly-DCPD will be determined. These formulations will be tested to characterize and verify suitability towards the target application. Process test samples will be produced and tested to qualify the process and formulations to the application.

PHASE II: Full scale prototype parts will be manufactured to demonstrate the application, process, and material formulation utility. Once the prototype parts have been manufactured, a test and evaluation program will be performed to verify the application, process and material formulation technology.

PHASE III DUAL USE APPLICATIONS: A successful program will transition into a Phase III application that will take advantage of poly-DCPD's superior mechanical and chemical properties. Applications requiring high-performance engineering material characterizes are plentiful. In particular poly-DCPD is likely to replace epoxies in a number of applications where mechanical toughness and extreme temperature stability are required. Poly-DCPD during processing will also replace epoxies in many applications where material voids and resin penetration is required.

REFERENCES:
1. Humble, R.W., "Dicylclopentadiene: A New Resin System for Making Composite TankStructures," 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 16-19 July 2000, Huntsville, Alabama, AIAA-2000-3676 http://www.aiaa.org/.

KEYWORDS: Plastic, Fiber Reinforcement, Rotational Molding, Dicyclopentadiene, Epoxy, Composite Matrix.

DARPA SB032-050 TITLE: Meso-Sensor Power Supplies

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

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OBJECTIVE: Develop novel means of powering very small sensors that are extremely volume and weight constrained to extend the lifetime of these devices.

DESCRIPTION: There has been significant development in recent years in what might be called "mesocopic sensors" or those ranging in sizes from about a 1 cm3 down to around 1 mm3 or less. These devices are useful for defense surveillance applications but also for home-land security, monitoring of private property, and other non-surveillance applications, such as process monitoring, medical monitoring, and other commercial sensing applications. Their small size allows them to be unobtrusive but it also imposes severe limitations on the volume of the device power-supply, thus limiting lifetime, as well as the ability to communicate its data for very long distances.

Unrelated to these devices is a wealth of on-going development work on batteries and power supplies, including so-called "power harvesting" techniques, which take advantage of ambient energy, such as light and heat, and convert it to electrical power. The vast majority of this work is targeted at much larger systems, such as man-portable sensors and communication devices. The requirements for these types of devices are vastly different than those for meso-sensors. Most notable are the severe volume and weight constraints of a meso-sensor compared with a man-portable

device. At the same time the power draw requirements are significantly different for the meso-sensor. Typical power draws for a man-portable device may be in the multiple watts range with a continuous load. In contrast meso-sensors may have peak power requirements on the order of milliwatts to hundreds of milliwatts but only at very low duty cycles. This leaves substantial time for recharging the device if some means of providing that charge were possible.

The objective of this solicitation is to develop novel power supplies tailored to the requirements and constraints of meso-sensor systems. The total power supply and storage component should consume no greater than a 0.1 cm3 volume and 1 cm2 area. The maximum peak power load is 0.5 W for duration of 1 minute followed by 14 minutes of a 1 μW draw. Given these requirements, the goal is to find a power solution that provides the greatest possible lifetime. The power supply may consist of a pure battery solution, but bidders are encouraged to combine scaled variants of power-harvesting technologies combined with ultra-efficient power storage as appropriate. Any idea for power harvesting may be considered, but example energy sources could include but are not limited to light, heat, vibration, linear motion, and wind.

PHASE I: Design, develop, and execute an experiment or appropriate study to demonstrate the proposed meso-sensor power supply concept and validate feasibility. Provide supporting analysis which shows feasibility of scaling of the device down to the desired size envelope.

PHASE II: Design, develop, and demonstrate a fully miniaturized prototype of the proposed Phase I meso-sensor power supply design concept, and provide an interface design to support the subsequent integration with potential sensors, which could make use of it.

PHASE III DUAL USE APPLICATIONS: The device produced in Phase II, or at least a component based upon its design, could be integrated with any number of possible meso-sensor devices. These could include acoustic sensors for perimeter and check-point monitoring, pressure sensors for smart structure monitoring, temperature sensors for health and process monitoring, and communications relays to extend the communications range of the meso-sensors.

REFERENCES:
1. For examples of state of the art power harvesting technologies, see the web site for the DARPA Palm Power program at: http://www.darpa.mil/dso/thrust/matdev/palmpower/
2. For examples of supercapacitor and thin film battery technology see:
Owens, Boone B.; Smyrl, William H; (Minnesota University - Minneapolis); "Thin Film Electrochemical Power Cells", Office of Naval Research Technical Report, (1991). (Available online from DTIC, http://stinet.dtic.mil/str/index.html, AD Number: ADA245176)
3. NASA Glenn Research Center, Photovoltaic & Space Environments Branch: http://powerweb.grc.nasa.gov/pvsee/programs/thinfilm/tfg_lab.html.

KEYWORDS: Batteries, Power Supplies, Power Storage, Energy Conversion, Power Harvesting, Sensors, Communications, Miniaturization.

DARPA SB032-051 TITLE: Components for High Performance Nanosatellites

TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: Develop a series of components suitable for nanosatellites that expand their capabilities to approach the functionality of larger spacecraft.

DESCRIPTION: There is considerable excitement in the space community about the possibility of performing useful missions in space using vehicles that are much smaller in size than current spacecraft. Reduced size spacecraft would be useful because the cost of delivering them to orbit can be much less than for conventional spacecraft, for example because they ride to orbit "piggyback" or as a secondary payload. The vehicle cost should also be less than that of conventional spacecraft. Spacecraft in the mass range of 1 to 10 kilograms are often referred to as "nanosatellites." Some technologies, such as microelectromechanical systems (MEMS), support the

migration of functionality to the nanosatellite scale. However, the suite of useful missions for nanosatellites is limited by the dearth of spacecraft components of suitable scale. Present day nanosatellites are often drifting, uncontrolled packages of instrumentation of very limited capability. The vital functions of propulsion, power conversion and storage, attitude control, attitude sensing, data storage, command and data handling, and telemetry, tracking and control, are not well supported by component availability in nanosatellite versions. This SBIR topic would support the design and development of a number of small, low-cost nanosatellite components in these subsystem areas.

PHASE I: Conduct a feasibility study of a low-cost nanosatellite component or subsystem that supports one of the following spacecraft functional areas: propulsion, power conversion, power storage, attitude sensing, attitude control, data storage, command and data handling, or telemetry, tracking and control. Investigate the functionality of the design through computer simulation and engineering analysis. Analyze the performance requirements and resulting design parameters. Provide a rough order of magnitude of component cost in production.

PHASE II: Build a brassboard test item using non-flight hardware. Develop the necessary test support equipment to demonstrate test item functionality. Conduct testing as feasible in a simulated space environment (the use of space environmental chambers would be separately funded by the Government if required).

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used for university space programs, to significantly reduce the cost of flight programs while still providing realistic spacecraft design and fabrication experience for students.

REFERENCE:
1. Johnson, Tompkins and Truszkowski, "Information Systems for Nanosatellite Constellations," NASA Goddard Space Flight Center,
a. http://agents.gsfc.nasa.gov/papers/pdf/isnc.pdf
b. http://books.nap.edu/catalog/5958.html

KEYWORDS: Nanosatellite, Subsystem, Component, Miniaturization.

DARPA SB032-052 TITLE: Self-Contained Deorbit Package for Spacecraft

TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: Develop a motor for spacecraft orbit changing, deorbit and/or retirement maneuvers that substantially reduces the launch mass of a mission spacecraft, and that is also capable of being attached to the spacecraft and operating independent of the spacecraft bus power system.

DESCRIPTION: The cost of orbiting a spacecraft is linked to the mass of the spacecraft on the launch pad. Reducing this mass could enable the use of a smaller, less expensive launch vehicle, or launching multiple spacecraft on one launch vehicle. A large mass component of many spacecraft is the propellant mass that is set aside for a retirement maneuver at the end of the spacecraft mission or life. For a mission altitude at the high end of what is normally called low earth orbit, 700 to 1400 kilometers, this retirement propellant reserve can be 10% or more of the launch mass. Several new technologies which use fuel more efficiently have the potential to reduce this penalty significantly. These technologies fall into two classes: (1) high specific impulse engines, such as Hall thrusters and ion engines; (2) propellantless concepts such as electrodynamic tethers. Such motors could be incorporated in future spacecraft to reduce launch mass. In addition, it could be desirable to attach such a motor to a spacecraft after launch using a robotic transfer vehicle. For example, a spacecraft could have experienced an anomaly which renders it uncommandable; attaching a deorbit package would restore a safe retirement capability. Or, a piece of catalogued debris could project a conjunction with an orbiting asset; attaching this package to the debris could mitigate the hazard without requiring the asset to maneuver.

PHASE I: Determine the feasibility of a self-contained deorbit package for external, on-orbit installation on a spacecraft or catalogued debris object. Investigate the functionality of the design through computer simulation

against current publicly available spacecraft specifications. Analyze the performance requirements and resulting design parameters. Investigate high-level software design requirements for the system and ground operations considerations.

PHASE II: Build a brassboard deorbit system using non-flight hardware. Develop software necessary to operate and communicate with the package from existing ground stations. Conduct testing as feasible in a simulated space environment (the use of space environmental chambers would be separately funded by the Government if required).

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used for commercial telecommunications and other spacecraft, to significantly reduce their launch mass for a cost savings to the spacecraft operator.

REFERENCE:
1. Orbital Debris Program Office, "Satellite Breakups Remain a Problem After 40 Years," Orbital Debris Quarterly News, v. 7, i. 3, NASA Johnson Space Center, http://see.msfc.nasa.gov/mod/modtech.html.

KEYWORDS: Orbital Debris, Spacecraft Propulsion, Access to Space.