DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
SBIR 2005.2 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. In accordance with Executive Order 13329, DARPA is also pursuing manufacturing-related R&D through manufacturing processes, equipment and systems protection.

DARPA has identified technical topics to which small businesses may respond in the second fiscal year (FY) 2005 solicitation (FY 2005.2). 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) of the program solicitation. A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

DARPA requires electronic submission of Cover Sheets, Technical and Cost proposals, and Company Commercialization Reports. Only proposals submitted through the on-line submission site at www.dodsbir.net/submission will be processed or considered for award. Proposals must be prepared and submitted in accordance with the DoD Program Solicitation at www.dodsbir.net/solicitation and the following instructions below.

PLEASE DO NOT ENCRYPT OR PASSWORD PROTECT YOUR TECHNICAL PROPOSAL

HELPFUL HINTS:

1. Consider the file size of the technical 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 Help Desk if you have submission problems: 866-724-7457
6. DARPA will not accept proposal submissions by electronic facsimile (fax) or email.

DARPA Phase I awards will be Firm Fixed Price contracts.

Phase I proposals shall not exceed $99,000, and should be a **6-month effort**.

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). Phase II invitations will be based on the technical results reflected in the Phase I draft and/or final report as evaluated by the DARPA Program Manager utilizing the criteria in Section 4.3. 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 1-888-227-2423 or Internet at 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 within DARPA for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in Section 4.2 of 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. **GOVERNMENT 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 will process 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 7^{th} 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.

DARPA FY2005.2 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 forward 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 ______

k. Consultants ______

l. Prior, Current, or Pending Support ______

m. Cost Proposal ______

n. Company Commercialization

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LCPOF 003
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Magnetic Resonance Imaging 001
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Microwave 001
Mid-Infrared 027
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MRI 001
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DARPA SBIR 05.2 Topic Index

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SB052-001 TITLE: Pulse Propagation in Negative Index Materials Having a Nonlinear, Positive Index, Host Medium

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Negative index materials (NIMs) are very promising for applications ranging from Magnetic Resonance Imaging (MRI) and radar to optical devices for communication networks. To date, most attention has focused on the structures to provide a negative electric permittivity and a negative magnetic permeability with little thought to the host medium. The typical host medium is almost entirely air except for a substrate to support the electric and magnetic "atoms." Another, older field which has proven applications is nonlinear optics. The objective of this task is to join these two fields, nonlinear optics and NIMs, by using a host medium with a nonlinear optical response to create new devices with previously inconceivable properties.

DESCRIPTION: There has been tremendous interest in the past few years in NIMs, also referred to as left-handed (LH) or metamaterials [see Ref. 1 and references therein for a review of NIMs]. NIMs exhibit simultaneously a negative electric permittivity and magnetic permeability such that the index of refraction is negative. A material exhibiting a negative index of refraction has unusual properties such as negative refraction. Even though NIMs were predicted nearly 40 years ago, it was not until recently that such materials were demonstrated, as materials that exhibit both negative electric permittivity and magnetic permeability are not found in nature. A number of interesting new features have been predicted, including sub-wavelength imaging. Although some doubts have been raised as to whether such materials are even physically possible or not, the issue seems to have been settled with recent experimental demonstrations in the microwave regime and numerical simulations [Ref. 2-3]. This has led to a large number of theoretical and experimental studies. Up to now NIM structures have been fabricated only in the microwave frequency regime, but recent developments have extended the frequency range up to 100 THz [Ref. 4]. Further understanding of NIMs could lead to completely new electronic and optical devices, particularly by combining NIMs with different nonlinear host materials. Nonlinear optical materials have been extensively studied since the invention of the laser. Proven application areas of nonlinear optical materials include second harmonic generation, optical limiting, laser modelocking, parametric mixing, and optical switching, just to name a few [see Ref. 5 for a comprehensive review of nonlinear optics]. Combining NIMs with nonlinear optical properties could enhance existing devices or provide devices with properties never before imagined. It is apparent that a medium that is dispersive in both electric permittivity and magnetic permeability calls for a re-examination of electromagnetic field interactions with such a medium. It is expected that a nonlinear host NIM will exhibit a rich spatio-temporal dynamics where both linear and nonlinear effective properties can be tailored by simply engineering the host medium.

PHASE I: Conduct a complete analysis of linear and nonlinear pulse propagation, including transverse effects, in a NIM having a nonlinear host to identify device applications.

PHASE II: Design and develop a nonlinear host NIM device in the THz frequency regime to experimentally study short pulse propagation effects in such a structure.

PHASE III DUAL USE APPLICATIONS: Successful completion of this research will lead to significant enhancements in medical imaging, civilian and military radar systems, and civilian and military optical communication networks.

REFERENCES:
1. D.R. Smith, J.B. Pendry, and M.C.K. Wiltshire, Metamaterials and Negative Refractive Index, Science vol. 305 p.788 (2004).
2. R.A. Shelby, D.R. Smith, and S. Schultz, Experimental verification of a negative index of refraction, Science vol. 292, p.77 (2001).
3. A. Grbic and G.V. Eleftheriades, Overcoming the diffraction limit with a planar left-handed transmission line lens" Physical Review Letters, vol. 92, p.117403 (2004).
4. S. Linden et al. Magnetic response of metamaterials at 100THz, Science vol. 306, p. 1351 (2004).

5. Robert W. Boyd, Nonlinear Optics, Elsevier Science & Technology Books, 2nd Ed. New York, NY (2003).

KEYWORDS: MRI, Magnetic Resonance Imaging, Communications, Networks, Nonlinear Optics, Microwave, Simulation, Metamaterials, Imaging.

SB052-002 TITLE: Opto-Mechanical Modeling of Low Cost, High Precision, Micro Components for Fiber Optic Gyroscopes

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics

OBJECTIVE: The objective of this effort is to develop an optical propagation model for low cost, high precision, Fiber Optic Gyroscope (FOG) micro sensor coils. The goal is to understand deleterious optical and mechanical effects and improve the state-of-the-art of low cost, micro sensor coil technology for FOGs. A validated model of low cost, micro components will permit optimization of sensor coil performance, improved sensor repeatability, and improved manufacturability of micro sensor coils.

DESCRIPTION: Low cost, precision, miniature inertial sensors are needed to enable non-Global Positioning System (GPS) navigation, guidance and control of ground and air unmanned vehicles, small diameter missile and rocket systems, and small platforms and robotic systems. Currently, Microelectromechanical Systems (MEMS) technology provides for low cost inertial sensors in the tactical grade regime only. The high precision performance arena, which includes non-GPS navigation for lengthy periods, miniature inertial measurement units (IMUs) for unmanned vehicles, and guidance and control of small diameter, long range missile systems, must be addressed by technologies other than MEMS. The FOG has the ability to address cost, size, and performance for these applications. To advance the possibility of a FOG solution for the strategic arena, several tasks should be performed. Modeling of micro FOG technology should examine the consequences of light source instabilities, propagation losses, mode coupling, polarization noise and fading, electro-optic effects, and thermal and stress gradients. Understanding and reducing the number and severity of these contributions will result in improved FOG performance and manufacturability. Topics to be addressed include light source fluctuations, polarization extinction due to absorption and scattering, coil diameter effects, polarization control through stress-induced birefringence, thermal and mechanical stability, and micro component performance repeatability.

PHASE I: Identify a discrete set of components that will be the basis for an opto-mechanical modeling tool-kit for low cost, high precision, micro FOGs. The tool-kit components should include source and fiber propagation properties, and detector optical characteristics. Define performance metrics for expanding and validating the model. Define testing procedures that allow for analysis and validation of the model. This validation process should encompass coil and system level testing and analyses.

PHASE II: Develop the opto-mechanical modeling tool-kit of discrete components for low cost, high precision, micro FOGs based on components identified in Phase I. Validate and model the integration and interaction of components. Integrate the model so that it describes the complete system. Optimize manufacturing by developing a prototype design based on model predictions. Build a newly optimized prototype and perform testing. Testing should include overall FOG performance characterization in terms of bias drift. During all phases of overall research and development in Phase II, concurrent modeling will occur.

PHASE III DUAL USE APPLICATIONS: The development of advanced low cost, high precision, micro sensor coils as described herein will result in high performance, low cost, inertial systems capable of being implemented into military, space, and commercial applications. These advancements can be implemented into the manufacturing processes of low cost, micro sensor coil winding to produce efficient and improved precision coil winding techniques. Military and space applications include attitude heading and reference systems (AHRS), navigation, and guidance and control of aircraft, missiles, automobiles, robots and satellites. Commercial applications in the aerospace and automotive industries have great potential as well as areas of commercial optical systems, robotics, and image platform stabilization.

KEYWORDS: Opto Mechanical Modeling, Fiber Optic, Micro Sensor, Coil Technology, Microelectromechanical, Navigation, Manufacturing Processes, Manufacturability.

SB052-003 TITLE: Smoke and Flame Resistant Large Core Plastic Optical Fiber for Highly Efficient Light Distribution in Navy Vessels

TECHNOLOGY AREAS: Electronics

OBJECTION: Develop necessary materials and processing techniques that render a large core plastic optical fiber that yields low smoke and burn rates as to comply with safety / hazard requirements for Navy vessel air spaces while maintaining optical efficiency (visible spectrum) and mechanical characteristics amenable for use in distributed lighting.

DESCRIPTION: Remote source distributed lighting, utilizing large core optical fiber, can provide highly efficient lighting solutions for virtually all shipboard lighting applications. Reduced maintenance, increased robustness and distribution of light without the associated electrical wiring are advantages.

These systems, with the associated advantages, make use of significant amounts of plastic in the construction of the optical fiber. The plastic materials typically used in large core optical fiber represent a potential smoke or flame risk constraining the proliferation of this technology.

A large core optical fiber is desired that is capable of withstanding flame and smoke generation requirements as defined in military specifications for Naval applications and that maintains optical efficiency and mechanical flexibility similar to or better than current Large Core Plastic Optical Fiber (LCPOF) technology.

PHASE I: Analyze and define the standards and test methods associated with smoke and flame risk. Perform research on the feasibility of materials, techniques and manufacturing processes available to achieve the required flammability requirements. Develop matrix of approaches that correspond to and allow for satisfaction of specifications of the standard.

PHASE II: Develop the cable design and fabricate prototype quantities available for performance and environmental testing. Conduct appropriate flammability and smoke generation testing on the prototype samples and characterize performance.

PHASE III DUAL USE APPLICATIONS: This technology could find widespread use in commercial buildings and retail stores. Large core plastic fiber composed of flame resistant materials and designs will allow large core optical fibers to be installed in commercial areas currently limited by building regulations.

REFERENCES: Distributed lighting is a central theme of DARPA's High Efficiency Distributed Lighting (HEDLight) program. References to the program may be found on the DARPA website.

KEYWORDS: Large Core Plastic Optical Fiber, LCPOF, Flammability, Smoke, Flame Resistant, Remote Source Distributed Lighting.

SB052-004 TITLE: Arc Source Multi-Layer Coatings to Doublelighting System Lifetimes without Affecting Performance

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Increase the lifetime of conventional metal halide lamps used for remote source lighting on Navy ships. Increased lifetime will lower maintenance burden and vastly reduce shipboard space and weight requirements for inventories of replacement lamps.

DESCRIPTION: Remote source lighting in ships and buildings provides benefits in terms of better visual acuity, lower energy load, and lower maintenance costs. The current systems employ a low wattage, high brightness High Intensity Discharge (HID) lamp as the light source. One remote source HID lamp can replace 2-6 fluorescent tubes and provides a lifetime comparable to the fluorescent lamps it replaces. Unique to HID lamps, application of advanced thin film coatings to the exterior of the lamp has the potential to significantly increase lifetime by reducing known failure mechanisms. Many of the life limiting means in the current remote source lighting HID lamp are related to unequal thermal distributions or contamination of the outer surface. By reducing the frequency of and vulnerability to these damaging conditions, a longer life lamp will be achieved. A multi-layer thin film coating applied uniformly on the lamp should be able to even out any thermal imbalances by recycling waste energy (Ultra Violet and Infrared) back into the lamp. This recycling has the possibility of also increasing the efficiency of the system as waste energy may be reemitted as visible light. Today's systems have a lamp chamber which is sealed to the environment. The lamp is sensitive, however, to dirt, grease and salts (including fingerprints) seen during storage and relamping. A thin film coating may help prevent reactions occurring between the lamp body material and contaminants by providing a barrier of inert material. Thin film coatings have been applied with very limited success only to high power HID lamps (1000 W +). This is partly due to the geometric constraints involved with line of sight coating methods. Shipboard remote source lighting systems use lamps that are lower power (< 100W) and higher brightness. These lamps will likely require uniform coatings on a complex geometry, a feature that traditional line of sight coaters are unlikely to be able to provide. Advanced coating techniques should be considered. The resulting lamps must be plug compatible to existing remote source lighting systems. It must be as rugged and reliable as existing lamps; it must not add weight or size.

PHASE I: Evaluate feasibility of exterior barrier coatings on remote source HID lamps. Coat lamps with preliminary designs and measure thermal distributions. Detail likely design space (materials, coating methods, annealing methods) for large scale success.

PHASE II: Develop detailed designs, coating process, annealing process and tooling design. Determine effect of using evenly applied coatings (low pressure chemical vapor deposition) vs. uneven coatings applied by line-of-sight coating methods. Produce prototypes. Publish life and photometry effects of these coatings.

PHASE III DUAL USE APPLICATIONS: The technology will support ground and sea vehicles and reduce logistics requirements. It will also be used in commercial and retail lighting applications. Longer lamp life translates to fewer lamp changes in the commercial applications of these lamps in office buildings and retail stores. New Department of Energy regulations on power consumption allocated to lighting will drive a larger installed base in the future. This will provide a large market and sufficient economies of scale to keep the cost of coating low.

REFERENCES:
1. Fullerton, Kathy and Lamouri, Abbas, "Color Control Coatings for Metal Halide Arc Lamps", 9th International Symposium on the Science and Technology of Light Sources; LS:9; Cornell University, Aug 12-16, 2001.
2. US Patent 5,552,671 Parham, Tom of GE - discloses UV blocking coatings.
3. US Patent 5,464,472 Horikoshi of Iwaski - discloses a multilayer coating on an arc tube for CCT adjustment.

KEYWORDS: Multi Layer Thin Film, Low Pressure Chemical Vapor Deposition, Low Pressure Chemical Vapor Deposition (LPCVD), Remote Source Lighting, Thin Film Coatings.

SB052-005 TITLE: <u>Situational Awareness of Computing Assets Outside of Direct Control</u>

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Design and build a system that provides a commander with situational awareness of the location and mission of computing assets, progress of mission, social network of assets, and vulnerabilities of assets, which, if exploited, could disrupt the mission tempo. Assume that the data upon which these visual representations will be based on may be unreliable, inconsistent or, in some cases, unknown.

DESCRIPTION: Information networks are becoming increasingly central to combat operations, presenting both new challenges and new opportunities to varied echelons in the defense community, from Computer Network Operations (CNO) to combat operations. Imagine, for example, Special Forces operating in hostile territory using a combination of fixed and mobile assets (perhaps even, including captured enemy equipment) that communicate through a loosely coupled data network. The challenge is to monitor those assets within hostile territory to assess mission progress; and further, to identify vulnerable assets where an adversary could insert attacks that disrupt the mission. New techniques are needed for synthesizing and presenting information to commanders and operators to provide full situational awareness of network state, vulnerability to attack, and mission impact of an attack. To meet the needs of these diverse missions the system developed here should: be scalable, providing a range of perspectives from sky to on-the-ground views; incorporate temporal qualities to present and project the timing and progress of missions; highlight known vulnerabilities in the network; incorporate mission criticality of assets so the potential impact of those vulnerabilities can be gauged; and show potential paths that an adversary could take in order to disrupt the mission tempo. These capabilities must take into account the unknowns, that the data may include margins of error, potentially unreliable information, or may be based upon conflicting data, and present those unknowns to the commander so that all decisions can be made in the proper context. Development of this system must be based upon a study of the requirements of the diverse missions that are affected or supported by the capabilities described here. Where possible, contractor should leverage existing technology for presenting location-based information in forms familiar to operational commanders, and that are consistent with existing defense systems.

PHASE I: Define the requirements, design the interfaces, mock up an interface to determine its usefulness to a commander.

PHASE II: Develop and demonstrate a prototype system in a realistic environment, potentially including formal military exercises and/or demonstrations.

PHASE III DUAL USE APPLICATIONS: This technology will be used in military situational awareness. It could be of great value in emergency response applications, where the need to develop and monitor a network of responders under hostile conditions offers many parallels to the problem defined here.

REFERENCES:
1. Field Manual (FM) 3-13: Information Operations: Doctrine, Tactics, Techniques, and Procedures. Headquarters, Department of the Army, 28 November 2003 (This publication supersedes FM 100-6, 27 August 1996).
2. Joint IO Planning Handbook. Joint Command, Control and Information Warfare School Joint Forces Staff College, National Defense University, July 2003.
3. Lintumaa, Kai. Do We Really Know What's Going On and Who the Enemy Is? Answer: Not Really. SANS GIAC certification paper. www.giac.org/practical/Kai_Lintumaa_GSEC.doc.
4. Teates, H. Bennett. Information Command and Control. Johns Hopkins University Applied Physics Laboratory. Presented at 2004 Command and Control Research and Technology Symposium (CCRTS), San Diego, CA., March 2004. www.dodccrp.org/events/2004/ CCRTS_San_Diego/CD/papers/189.pdf.
5. Tinnel, Laura, Saydjari, O. Sami, and Haines, Joshua. An Integrated Cyber Panel System. DARPA Information Survivability Conference and Exposition (DISCEX) III, Crystal City, VA, April 2003. http://csdl.computer.org/comp/proceedings/discex/2003/1897/02/18970032abs.htm.

KEYWORDS: Mission Impact, Situational Awareness, CNO, Data Presentation

SB052-006 TITLE: <u>Integrated Radio-Frequency Functionality in Wireless Sensor Networks</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: To reduce size, cost, and energy consumption of deployable sensor nodes by development of algorithms, protocols, or devices that integrate radio-frequency (RF) communications and sensing functionality.

DESCRIPTION: Recent advances in low-power component technology and protocols for communication and sensing have made the idea of deploying large sensor networks attractive for numerous defense, homeland security, and civilian applications. Such systems usually consist of a large number of nodes, each of which contains one or more sensors, a communication subsystem, a processor, and possibly additional components such as Global Positioning System (GPS) receivers and self calibration and test equipment. Many prototype sensor systems have been deployed in short-term tests and demonstrations. Size, cost, and especially energy consumption remain significant barriers to long-term deployment for many potential applications; however, one approach to address this issue is integration of the functionality of various subsystems in ways that decrease these key metrics for the overall system. The communications subsystem is essential to nodes of this type and it often shares many technological fundamentals with other RF subsystems, particularly RF sensors and geo-location subsystems. Thus the communications system provides a natural hub for integration of RF functionality in sensor nodes.

Innovative mechanisms, including algorithms, protocols, and devices, for integration of RF functionality in deployable sensor nodes are sought under this topic. These mechanisms should support the reduction of total node size, cost, and energy consumption. Technology developed under this topic should be complementary to and combinable with other new technologies, such as improved power supplies, which enable longer service life and increased deployability of wireless sensor nodes.

PHASE I: The contractor will study the feasibility of novel mechanisms to integrate RF functionality in deployable, wireless sensor nodes. The feasibility study may examine innovative algorithms, protocols, devices, or combinations of these elements and should include analysis and/or simulation to support assessment of the impact of the technology developed on sensor node size, cost, and energy consumption. It should also address the versatility of the solution by clearly defining the assumptions and limitations on operational parameters it entails. Concepts that reduce the number of independent subsystems necessary to achieve a desired level of performance are of particular interest.

PHASE II: The contractor will develop, demonstrate, and deliver prototype sensor nodes incorporating the technology developed. The demonstration should be in the form of a field test in which the capabilities of the nodes are evaluated in the context of a militarily significant mission. The number of network nodes used in the test should be sufficient to mimic an actual deployment.

PHASE III DUAL USE APPLICATIONS: Long-lifetime, miniature, deployable sensor devices are essential for future DoD capabilities. Technology developed under this topic has wide applicability to sensor networks envisioned for military applications (intelligence preparation of the battlefield, perimeter monitoring), homeland security (radiation and chemical-biological hazard monitoring), and civil applications (environmental monitoring, natural disaster assessment, security.)

REFERENCES:
1. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “A survey on sensor networks,” IEEE Communications Magazine, vol. 40(8), pp. 102–114, August 2002.
2. E.H. Callaway, Jr., Wireless Sensor Networks - Architectures and Protocols, Auerbach Publications, 2003.
3. G.J. Pottie and W.J. Kaiser, “Wireless integrated network sensors,” Communications of the ACM, vol. 43(5), pp. 51–58, May 2000.
4. IEEE Std 802.15.4™-2003, “Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR_WPANs),” 1 October, 2003, SH95127, SS95127.
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KEYWORDS: Sensor Networks; Wireless Communications

SB052-007 TITLE: <u>Rapid, Non-Invasive Radiation Bio-Dosimeter</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Nuclear Technology

OBJECTIVE: Identify and develop innovative technology to assess the absorbed dose of radiation received using rapid, non-invasive technology.

DESCRIPTION: In the event of an unexpected radiation emergency, the development of rapid non-invasive methods of radiation exposure assessment will be essential to minimizing radiation damage. Current state of the art technology is primarily focused on chromosomal aberration assays such as dicentric analysis of circulating lymphocytes. The approach is time consuming, expensive and requires highly trained scientists. It also requires that a blood sample be taken by a trained medical worker, processed in a laboratory and analyzed on specialized laboratory equipment. The results are usually available within two or three days. Other promising areas using invasive dosimetry currently being investigated, in order to determine the absorbed radiation dose include quantitative determination of phosphorylation at the broken DNA sites, novel protein biomarkers that are present in damaged cells, and gene expression profiles using modern biochip technology. All of these invasive approaches have significant limitations that would hamper a rapid dose assessment to irradiated individuals. Estimating nuclear exposure rapidly and inexpensively using non-invasive, on-site methods is a critical component important in triaging and determining subsequent treatment of the radiation injury following a Weapons of Mass Destruction (WMD) attack. Assessing both the exposure level as well as who was and was not exposed to radiation will be important in providing rapid treatment capability to only exposed individuals following a terrorist attack using on-site instrumentation. Therefore, the development of a rapid, non-invasive, on-site determination of radiation exposure is requested. Examples of non-invasive analysis could include, hair, sweat, urine, breath, and teeth (in situ) and bones (in situ) that could be analyzed rapidly using instrumentation on-site following exposure. References of some prior work are included below.

PHASE I: Conduct initial research to develop a technology and conduct preliminary data demonstrating that a rapid evaluation of the presumed exposed individual within (15 – 30 minutes or less) is possible.

PHASE II: Develop and demonstrate a prototype which provides sensitivity levels (minimum and maximum). Conduct studies that demonstrate how long after exposure the test is valid.

PHASE III DUAL USE APPLICATIONS: The technology and data developed under this SBIR can be used in military and civilian scenarios requiring rapid triage following a dirty bomb exposure. The technology would be useful for solving the increased capacity of biological dosimetry required in response to a large scale radiological and nuclear event for rapid and non-invasive assessment of radiation exposure.

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KEYWORDS: Non-Invasive, Rapid, Radiation Bio-Detection.

SB052-008 TITLE: Smart Scalpel

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Design and build a surgical scalpel which contains sensor and/or actuators that provide capabilities for the surgeon that are beyond natural human capabilities.

DESCRIPTION: Many developments in microelectromechanical systems (MEMS), photonics (including light emitting diodes, femtosecond lasers, micro ultrasound arrays, Raman spectroscopy, etc.), hold out promise to embed these systems into a surgical scalpel to add real-time diagnostic capabilities, or to give novel therapeutic advantage beyond simply cutting with the scalpel.

PHASE I: Create a design for a surgical instrument, preferably a scalpel, which adds one additional diagnostic or therapeutic modality.

PHASE II: Develop and demonstrate a prototype scalpel that can provide such a diagnostic or therapeutic capability. This must be beyond current technology such as radio-frequency ablation, cryotherapy, electrocoagulation and high intensity focused ultrasound (HIFU).

PHASE III DUAL USE APPLICATIONS: This prototype instrument will add additional capabilities for civilian medical care and field surgery, such as rugged, reduced size, etc.

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KEYWORDS: Scalpel, Activators, Sensor

SB052-009 TITLE: Information Delivery and Display for Shared Awareness in the Net Centric Battlespace

TECHNOLOGY AREAS: Information Systems, Battlespace, Human Systems

OBJECTIVE: The goal of this topic is to develop information delivery solutions that will specifically enhance warfighter performance in the context of the "Net Centric Battlespace," and take advantage of the developing revolutionary command, control and communications capabilities. The ultimate goal of this effort is to demonstrate advanced human systems integration and establish how communities of decision-makers can achieve profound improvements in their ability to exchange meaningful information and create a common operational picture to successfully plan and execute complex, collaborative missions.

DESCRIPTION: There has been a great deal of emphasis placed on the concept of Network Centric Warfare in the past several years. The U.S. Navy has embraced this model, with its current implementation of FORCEnet, in which the command and control architecture becomes a "comprehensive network of sensors, analysis tools, and decision aids to support the full array of naval activities, from combat operations to logistics and personnel development." (VADM Mayo, Feb 2003) While the importance of the "human in the loop" has been emphasized, there has been little work done to analyze the impact of this architecture on the individual operator. Persistent and pervasive sensors, rapid action requirements, and reduced manning initiatives necessitate the development of methods for transforming information delivery, instilling knowledge and enabling an understanding of military decision-makers operations within this seamless, networked environment. In addition to challenges to the individual operator, the military is currently using ad hoc solutions to tackle the shared awareness issues inherent in distributed command and control – cell phones, two way pagers, text-based chat (e.g. Internet Relay Chat (IRC), Lotus Sametime, etc.) and instant messenger applications have filled in the gaps where tools specifically designed for collaboration are noticeably absent. This lack of formal policy or an empirical understanding of best practices requires remediation. Future military operations will continue to be Joint and Coalition efforts in the 21st century, thus the transformation of data into actionable knowledge and its fusion into a common operational picture is critical for all of our Services and allies. The creation of a ubiquitous Battlespace that will allow and ensure that data becomes information and knowledge remains a significant challenge: we must ensure that 1) data is presented to all manner of war fighters as meaningful, actionable information and thereby becomes internalized as knowledge, and 2) effective collaborative tools exist that facilitate knowledge sharing.

PHASE I: Phase 1 of this effort should involve an analysis of a specific task environment and how it might benefit from recent developments in knowledge management, information science, cognitive science/neuroscience, human factors and basic psychological research. The emphasis should be on providing a basis for measurably improving the speed and quality of both individual and group decision-making. Include the development and/or elaboration of theory for the exchange of information between humans, and/or human – machines in complex systems.

PHASE II: Phase 2 of this effort should involve the design and testing of prototype technologies for the target application environment, which would be a node in the FORCEnet concept of operations - as investigated in Phase 1. Direct relevance to the developing Network Centric/FORCEnet operating environments should be incorporated and strategies for insertion into a networked battlespace should be evaluated. If robust enough, a prototype Phase 2 system could be tested in a Fleet Battle Experiment or other Joint and/or Coalition exercises.

PHASE III DUAL USE APPLICATIONS: This topic has many dual use applications, including the development of novel business networking tools and information management techniques for inclusion in multiple domains. The applications to the military environment are substantial, and this topic could provide critical solutions to any number of Services, Joint and Coalition operations in the Net Centric Battlespace.

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KEYWORDS: Human Systems Integration; Net Centric Warfare, Collaborative Command and Control; FORCEnet; Shared Awareness.

SB052-010 TITLE: Special-Purpose Computing for Neurobiologically Inspired Networks

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Biomedical, Electronics

OBJECTIVE: Develop an embedded computer specific for neurobiologically based neural networks, suitable for deployment on an autonomous device.

DESCRIPTION: Machines that follow neurobiological principles in their construction are critical for the development of intelligent devices capable of adaptive, autonomous behavior. Operating a biologically-based neuronal network is computationally intensive due to the large number of simulated neurons, synaptic connections between neurons, and the constraints of its neuroanatomy. In general, the asynchronous, parallel computation of a nervous system is not a good fit with a conventional serial computer. A typical neural simulation iterates a single neural activation function over tens to hundreds of thousands of neuronal units and iterates a synaptic plasticity rule over millions of synaptic connections. The varying factor in these calculations is the connectivity of the neural network or its neuroanatomy. For a neural simulation to be realizable in a real-world environment, these calculations must be completed across the entire neural network in tens of milliseconds or less. Moreover, for the device to be autonomous, the computer must have low power consumption and a small footprint. This topic seeks to encourage the development of computers specifically designed for neural computation that take into consideration the parallel nature of these calculations and that are feasible for field operations, in contrast to laboratory settings.

PHASE I: Evaluate the considerations for a computer specifically designed for neural computation. Conduct studies to determine the feasibility of making such computers portable and fieldable.

PHASE II: Develop a prototype device for use in a robotic application, in which the device is actively engaging in a mission where rapid action in response to environmental inputs is critical.

PHASE III DUAL USE APPLICATIONS: The development of computers specifically designed for neural computation has applications in military and commercial settings. The technologies under development will find commercial applications in mobile autonomous devices such as those used for search and rescue, mine sweeping, and surveillance, as well as in unmanned air and sea vehicles or anthropomorphic effectors and multi-modal perception systems for medical use.

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KEYWORDS: Neural Computation; Advanced Computation; Intelligent Devices; Autonomous Robotics

SB052-011 TITLE: Embedded Capability-Based Operating Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Demonstrate applications of capability-based operating systems in embedded systems environments.

DESCRIPTION: Capability-based operating systems have shown advantages in applying the principle of least privilege [1,2]. DARPA is interested in the application of the capability idea – access to resources via unforgeable capabilities – to resource management in embedded systems. These systems often have severe constraints – power, space, real-time and reliability – which capability systems seem well-poised to address. In particular, capabilities seem attractive in supporting the composition of embedded systems into “systems of systems,” and providing robust resource control in such an environment.

PHASE I: Prepare a feasibility study for a capability-based operating system to demonstrate operation of a single application on an appropriate embedded processing platform.

PHASE II: The capability-based operating system would be demonstrated in a scenario where a computer running a general purpose commercial operating system was able to remotely access services on the embedded system, e.g., through a Universal Serial Bus (USB) port.

PHASE III DUAL USE APPLICATIONS: Embedded systems are increasingly part of the “systems of systems” within which users operate, both in the commercial world and in the network centric battlespace. Trusted embedded systems software will be an essential component of these systems and the properties of the software systems which manage embedded systems resources will be critical. Unless systems with security properties such as those of EROS [1,2] are used to build these systems, their security and reliability will be suspect. It is anticipated that if this effort is successful, applications will range from commercial applications of microcontrollers (electronic controls, computerized sensor/actuator systems, fuel injectors, embedded communications devices) to uses of embedded systems in military domains (battlefield sensors, aircraft control systems, computer/human interfaces).

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KEYWORDS: Operating Systems, Embedded Systems, Security.

SB052-012 TITLE: Non-Intrusive Health Monitoring for Post-Battle Wellness Management

TECHNOLOGY AREAS: Information Systems, Biomedical

OBJECTIVE: Create supportive and non-intrusive health-monitoring technologies that will facilitate the transition of injured combat veterans into extended care and independent living environments.

DESCRIPTION: Long-term support and care of military personnel is of paramount importance to the Department of Defense. The need for high-quality monitoring of the medical condition of soldiers recovering from battle-related injuries can significantly delay, and in some cases prevent, their return to independent living. DARPA is interested in the development of innovative, low-cost, non-invasive “trip-wire” systems capable of monitoring injured and recovering veterans and detecting problems with their recovery. The envisioned health-monitoring system is expected to provide both a safety net that can detect when the soldier needs assistance and a detection/prediction capability that enables the system to advise health care providers of changes in important medical indicators, e.g., decrease in mobility. In terms of technical approach, this implies that simple sensor-only solutions will not be effective. Instead, solutions must integrate Artificial Intelligence (AI) or cognitive systems technologies with sensors (or sensor data), to provide a reasoning capability that enables the system to detect and diagnose trends rather than monitor for single data points. To illustrate, a 30% decrease in mobility over a one week period is a trend whereas a body temperature reading of 98F is a single data point. These capabilities are important to all recovering soldiers and are even more important to those who live alone. This research must address the challenges presented by a recovering soldier who is likely to be suffering from multiple injuries and is at the same time generally active. The recovering soldier is also likely to exhibit changing medical and behavioral profiles as he/she heals and becomes more adept at using wheel chairs, prosthetic limbs or other assistive devices. Conversely, in the early stages of using such devices or in the early stages of recovery, the likelihood of new injury or mishap is also greater. DARPA is seeking solutions that will benefit soldiers with a wide variety of impairments who are ready to make a transition back to independent life. Integrated approaches are preferred and should include technologies for in-home sensing, monitoring and diagnosing medical conditions, and communicating summary results and alerts to appropriate medical personnel. Proposed approaches must address reasoning with uncertainty, discriminating between changes that are within normal variation and those indicating a problem, and minimize false alarms. Offerors must describe how the proposed research effort will protect individual’s privacy rights, is cost effective, and does not place additional burden on healthcare professionals and volunteer caregivers (e.g., the person’s family). Possibly relevant technologies include Bayesian or other forms of probabilistic/uncertain reasoning, learning of probabilistic/uncertain models (both structural learning and parameter estimation), sensors and sensor fusion, human cognitive and behavioral modeling.

PHASE I: Perform initial assessment and specify the design of a system addressing these requirements. Include a plan to demonstrate the relevance for the proposed system.

PHASE II: Expand the concept developed under Phase I. Develop a complete demonstration system and demonstrate performance in a variety of hypothetical scenarios.

PHASE III DUAL USE APPLICATIONS: The technology developed in this topic is applicable to monitoring injured soldiers and other at-risk individuals, including those that experience traumatic events or have chronic medical conditions, e.g., fragile diabetics.

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KEYWORDS: Non-Invasive Medical Monitoring, Uncertainty, Cognitive Systems, Artificial Intelligence.

SB052-013 TITLE: Automated, Adaptive Vulnerability Assessment Tools

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a system that captures, extends, and applies expert knowledge to assess and prioritize evolving threats to military installations, driving continuous improvements in security readiness.

DESCRIPTION: Historically, force protection has focused on deterring and defeating attacks on point targets. As evidenced by the attacks of Sep 11, 2001, as well as the tactics of Iraqi insurgents and other terrorist groups, asymmetric warfare necessitates a change in that paradigm. In the presence of attacks focused on underlying or surrounding infrastructure (for example, the civilian infrastructure and population around a military base), point defense is no longer sufficient. The fundamental principles of military operations are still valid, but the tactics, techniques, and procedures used to apply them to this type of threat must change [1]. Specifically, assessments must address interdependencies and vulnerabilities of very different targets (fixed as well as mobile, permanent as well as temporary) across broad geographic areas and against a wide variety of attack methods. Classical risk assessment methodologies [2, 3] continue to evolve, are widely available, and in most cases are sufficient for assessing risks to a single building or small facility with clearly defined and well understood vulnerabilities. For large installations such as military bases, current assessment methods lack the needed capability of comparing, integrating, and prioritizing vulnerabilities involving multiple infrastructures in a larger geographic area. Any large military installation relies on numerous types of infrastructure, individually and collectively critical to carrying out the installation's mission. In one specific example, the base has several gas pipelines, fed by a "town border station" dozens of miles away, interfacing between a transmission pipeline and the local distribution network. Similarly, the base is served by one or more electrical substations, also remote from the base, as well as possessing on-site backup generation, with an accompanying store of diesel fuel sufficient for two to four days' supply. On the base, there are multiple mission-critical functions, each of which is served from a separate building: base HQ, including strategic command and the main communications nexus; tactical ops, providing logistical support including the current readiness posture; and the data center, providing core computing and networking services. Both on-base and external communication networks are provided by a combination of dedicated T1, fiber optics, and microwave relay. Additional infrastructure includes water supply, for human consumption, sanitation, and cooling (most critically for the data center.) Each of these systems is interdependent with the others. For example, gas-fired heating systems rely on electricity to run the pumps and fans. Each presents different levels of risk, and requires different preparation and expense for a successful attack. The most attractive attacks from the attackers' point of view are determined not only by the difficulty of the attack, but by their resources and objectives. For example, a terrorist attack focused on generating maximum media coverage might involve coordinated attacks on electrical transmission (at the remote substation), a gas leak just outside the installation boundary subsequently ignited to generate a fuel-air explosion, and disruption of the water supply to hinder fire-fighting efforts, timed to coincide with a large, planned gathering of military personnel. On the other hand, an attack aimed at disrupting the installation's support of an ongoing mission might target fuel deliveries, or Command, Control and Communications (C3) communications infrastructure, for example through a coordinated cyber attack on computer and networking facilities. DARPA seeks creative new approaches to providing automated vulnerability assessments that are robust, repeatable, and address infrastructure interdependences and evolving threats. When deployed, the solution should require only minimal training of security personnel and have a means to ensure the completeness and validity of the assessed data inputs. The solution should provide a means to capture existing expertise, incorporate the latest global and local intelligence, capture and securely share the knowledge created during assessments, and provide actionable output to enable base operations and security personnel to prioritize and direct security investments, enhance security training, and update policing procedures. Research Challenges: Providing an automated, adaptive vulnerability assessment tool will require innovative solutions to several interrelated problems:

•Representing the multiple infrastructures involved in such a way that interrelationships can be reasoned about. These relationships may include physical proximity, functional dependence, or synergy as a "covering set" (e.g., remove all sources of electrical power.)
•Representing the cost, time, resources, and risk involved in specific infrastructure attacks.
•Representing and reasoning about the objectives, resources, and capabilities of a potential attacker or attackers, in a form that supports reasoning about what kinds of attacks are most attractive/most likely for a given class of attacker.
•Knowledge capture for the process of vulnerability assessment, so that candidate vulnerabilities are generated and analyzed in a systematic, focused, and effective manner.
•Knowledge and model updating: the system must be able to incorporate new information, for example regarding infrastructure changes to the installation, or intelligence reports providing new data on attacker capabilities and objectives. The system should also be able to use the results of previous analyses (its own and others') in subsequent analysis.

Relevant Technologies: Potentially relevant technologies include automated reasoning systems (expert systems, proof verifiers, model checkers), dynamic logics and other means of automated scenario generation, heuristic search (for scenario generation), geometric and geographical representation and reasoning, cognitive modeling of the attacker, probabilistic and uncertain reasoning, and learning.

PHASE I: Prepare a feasibility study to design an automated system for vulnerability assessment. The study should include a plan which would perform analysis and outline a proof-of-concept demonstration addressing the technical challenges.

PHASE II: Expand the concept developed under Phase I. Develop a complete demonstration system and demonstrate performance in a variety of scenarios involving military installations of significant size.

PHASE III DUAL USE APPLICATIONS: The technology developed in this topic is also applicable to vulnerability assessments of other (non-military) installations and geographic areas and would be of use to federal, state and local governments and police departments. The underlying technology will also be adaptable to a wide range of commercial risk and vulnerability assessment applications.

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KEYWORDS: Knowledge Capture, Automated Reasoning and Learning, Vulnerability Assessment, Systems Analysis, Force Protection, Adaptive and Learning Systems.

SB052-014 TITLE: Distributed Collaborative Planning and Control for Undersea Surveillance using Swarms of Autonomous Underwater Vehicles

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Sensors

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

OBJECTIVE: To achieve an order of magnitude reduction in search times for localization and recognition of enemy undersea targets using a network of Autonomous Underwater Vehicles (AUVs) with distributed planning and control under minimal communication.

DESCRIPTION: The goal is to increase search rates and reduce false alarms rates for undersea surveillance of targets of opportunities. Recent developments in enhanced AUV capabilities and distributed planning and control of multi-agent systems offer a unique opportunity to satisfy this need. The basic constraint in undersea surveillance is very limited communication and high rate of false alarms. The use of a network of mobile (on AUVs) and stationary sensors is promising, but search planning and sensor management functions must be distributed and decentralized to minimize communication and maximize robustness to failures. The area of distributed collaborative planning and control of networked systems under communication constraints is an active area of research in control theory. The basic foundations of stochastic control under limited information were laid down by Witsenhausen over 30 years ago, but little progress has been made in solving these problems. The purpose of this effort is to develop distributed planning and control strategies for a network of AUVs to perform efficient search, localization, and tracking of dynamic targets. The goal of the effort is to demonstrate an order of magnitude improvement in undersea surveillance over current state-of-the-art.

PHASE I: Develop theoretically sound approaches for solving the distributed collaborative planning and control of a swarm of AUVs for efficient covert undersea surveillance. The planning and control functions will include path planning, collision avoidance, and sensor management. Demonstrate the results using high fidelity simulations.

PHASE II: Demonstrate the techniques and concepts developed in Phase I using a group of three or more people as surrogate AUVs in underwater environment. The goal of a Phase III would be to implement the technologies developed in Phase II on three AUVs and perform a hybrid demonstration to show scalability, and transition technology to Navy programs.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in other military and civilian commercial AUV applications such as undersea environmental prediction and mapping as well as undersea networking and communication systems.

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KEYWORDS: Surveillance, Autonomous Underwater Vehicles, AUV, Multi-Agent Systems, Mobile Sensors, Stationary Sensors, Communication Systems.

SB052-015 TITLE: <u>Advanced Technologies for Display of 3D Urban Models</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop novel and innovative methods for visualizing, portraying, rendering, and/or fabricating models of high-resolution 3D data of urban structures and scenes.

DESCRIPTION: Soldiers are often inserted into urban neighborhoods with 2D maps that include layouts of streets and buildings. Accurate, detailed 3D models of urban environments are rapidly becoming available using a variety of sources, such as Lasar Radar (LADAR), photogrammetry, stereo vision radar, video, and Computer-Aided Design (CAD) models. Concurrent advances in visualization and display technology are required to realize the full value of the newly available 3D models. Key challenges encountered in defense applications include: (1) developing a holistic 3D display of a scene, including building exteriors, interiors, trees, vegetation, signs, wires, and vehicles, from multiple perspectives and orientations; (2) design and development of large format displays that facilitate effective communication of geospatial structures among groups of people; (3) incorporation of dynamic and moving entities within 3D visualizations; and (4) facilitating high-fidelity walk-through of 3D scenes and structures. DARPA seeks novel methods to achieve these goals for high-resolution display of urban scenes, with emphasis placed on versatile, configurable display and visualization systems capable of sustaining dynamic, real-time updates. Approaches should incorporate new display modalities, rather than merely enabling faster rendering of complex scenes. Technologies can include, but are not limited to, 3D holography including compact, portable devices; dynamic holography; auto stereoscopic technology that augments 2D displays to provide stereoscopic viewing; or very rapid production of high-fidelity physical models such as 3D terrain models. Devices that increase the physical loadout of a soldier or impact mobility and agility, such as head-mounted devices, are not desired. Proposed solutions should be able to ingest standard 3D data formats at high data rates and at varying resolutions up to 1 cm. Radical advances are sought, not incremental improvements of existing approaches.

PHASE I: Develop the concept and system architecture for a 3D visualization system for exceptionally high resolution, finely detailed 3D data of urban environments. Identify key performance parameters and the performance thresholds that are achievable. Assess the feasibility of meeting them through rapid prototyping of key components or through mathematical analysis.

PHASE II: Develop and demonstrate a prototype display system as early as possible. Measure system performance in multiple dimensions, such as data processing load, human usability, scene complexity, and scene refresh rate. Based on feedback from the performance measurement activity, iteratively refine and enhance the technology to deliver a robust implementation demonstrable with prepackaged, time-sequenced, or live sensor input.

PHASE III DUAL USE APPLICATIONS: Technology developed under this effort will assist the soldier in uniform warfare and has numerous potential commercial applications, including law enforcement, urban planning, real estate, and virtual tours of public and private buildings, such as museums.

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KEYWORDS: Information Systems, Battlespace, Situational Awareness, Hologram, Holography, 3D Visualization, Urban Warfare.

SB052-016 TITLE: Advanced Radio Frequency Circulator Development

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Identify and develop innovative component technology supporting simultaneous transmit and receive (STAR) architectures for radio frequency (RF) systems.

DESCRIPTION: DoD is interested in substantially improving the productivity of their larger, more expensive active RF systems. It can be shown that in many applications these systems are timeline, not power-aperture limited. This is due to scheduling/timeline constraints imposed by the aperture. An example of such a constraint is the inability of current higher-power RF systems to support time-concurrent transmission and reception from the same aperture. Several component technologies must be developed before this type of concurrency is readily available. Current pulsed architectures typically use switches and circulators to provide isolation between transmit and receive ports. Switches are used to isolate transmit and receive circuitry by effectively turning off the receive port while transmitting. These switches preclude simultaneous transmit and receive and hence will not be a part of any STAR technology solution. The circulator, on the other hand, does not preclude STAR, does provides some isolation between transmit and receive ports, and hence worthy of study and development for STAR architectures. DARPA would like to focus development of circulators relevant to STAR architectures at microwave frequencies, most notably X-Band. In particular, DARPA is interested in circulators that provide much better trades into operational and instantaneous bandwidths (better than 15% instantaneous and 30% operational), insertion losses (not to exceed .5dB), power handling capabilities (in excess of a few Watts average), isolation between transmit and receive ports (greater than 40dB), and a form-factor such that it fits comfortably in an X-band lattice (~ ½ inch on a side) along with other transmit / receive circuitry.

PHASE I: Develop concepts for high performance circulators meeting or preferably exceeding expectations expressed above. Prepare a feasibility study to demonstrate the relevance of this type of technology.

PHASE II: Implement designs in hardware. Demonstrate performance through an appropriate series of measurements.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in other military and civilian commercial RF applications such as personal communications systems.

REFERENCES:
1. M. Skolnik, Radar Handbook, chapters 8 and 11, McGraw-Hill Book Company, 1970.

2. M. Meyer and H. Goldberg, “Applications of the Turnstile Junction”, IRE Transactions on Microwave Theory and Techniques, December 1955.

KEYWORDS: Simultaneous Transmit and Receive, Circulator, Isolator, T/R Module.

SB052-017 TITLE: Innovative Air System Survivability Concepts

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes

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

OBJECTIVE: The objective is to prototype innovative concepts that lead to improved air system survivability.

DESCRIPTION: Under the rubric of survivability, the principle dimensions are generally to be susceptibility and vulnerability. Susceptibility refers to the ability to avoid detection that leads to a weapons engagement. Recent tradition has broadly equated air vehicle survivability in a hostile environment with detectability. As such, the focus has been on practices and methods to reduce the electro-magnetic signature of the air vehicle below the threshold of detectability. Unquestionably, signature reduction will improve survivability but it is an expensive technique. Vulnerability refers to the ability of an air vehicle to withstand a weapons attack. That is, once damage occurs, the aircraft should retain the ability to continue its mission or safely return to base. Under this SBIR topic area, DoD is interested in innovative ideas and concepts that can improve the survivability of an aircraft system. An aircraft system for this effort is defined as a group of air vehicles cooperatively operating together for mutual support and benefit. Innovative concepts can be in the areas of materials, flight geometries, vehicle design, visual camouflage, electronic camouflage, damage tolerant flight controls, propulsion and fuel systems, improvements in self-defense, reduction in operator workload, increased autonomy and decision-making, and the like. Special emphasis should be given to enhanced survivability concepts that are enabled by multiple aircraft working in close consort.

PHASE I: Offerors should have an understanding of aircraft survivability methods and techniques to baseline the current state of the art in aircraft survivability. Propose non-traditional concepts that could lead to reduced combat air system susceptibility and vulnerability. Compare and contrast techniques and rank order concepts in terms of what provides the greatest increase in survivability for the lowest cost.

PHASE II: Prototype and demonstrate innovative survivability concepts in a laboratory environment. Assess the survivability concept(s) in terms of expected improvement in meeting mission objectives or returning safely to base.

PHASE III DUAL USE APPLICATIONS: Improvements in aircraft survivability may be transferred to the commercial aircraft community.

REFERENCES:
1. The Fundamentals of Aircraft Combat Survivability Analysis and Design, Second Edition, R. Ball, Naval Postgraduate School, 2003 AIAA Education Series.
2. Aircraft Survivability, A periodical published by the Joint Aeronautical Commander"s Group, Joint Technical Coordinating Group/Aircraft Survivability. Address: SURVIAC, WL/FIVS/SURVIAC, Wright-Patterson AFB, 45433-6553.

KEYWORDS: UAV, Survivability, Vulnerability, Susceptibility, Innovative Concepts.

SB052-018 TITLE: All Weather Target Sensing in Denied Airspace

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

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

OBJECTIVE: The objective is to develop and prototype concepts for low observable aircraft to sense and identify targets of interest in all weather conditions.

DESCRIPTION: Cloud cover and weather can be problematic to sensing and target identification. To extend and/or improve the sensing suite for the emerging Unmanned Combat Air Systems, innovative ideas are sought that will enable J-UCAS to sense and identify targets of interest in inclement weather conditions without yielding its inherent advantage in low observability. For example, an air deployable Unmanned Air Vehicle (UAV) containing an electro-optical sensor may penetrate the cloud cover and gives the combat air vehicle a sensor below the weather. Air-deployable UAVs have been demonstrated in the past. In any concept, consideration should be given to maintaining the low signature characteristics of the air vehicle. Also note that an Unmanned Combat Air System is comprised of multiple air vehicles.

PHASE I: Conduct overall system design trade studies comparing options to enable stealthy all weather sensing by a Unmanned Combat Air System. List the necessary technology enablers that must occur to realistically develop such a concept. Provide a technology roadmap to achieve the various concepts.

PHASE II: Prototype and demonstrate in a realistic environment the concept selected from Phase I. Conduct testing and analysis of performance. Suggest modifications to improve performance.

PHASE III DUAL USE APPLICATIONS: All weather sensing can be applied to the remote sensing scientific community, military and civilian.

REFERENCES:
1. Finder UAV, Naval Research Laboratory.
2. Silent Eye, Raytheon.

KEYWORDS: UAV, J-UCAS, Sensing, Electro-Optical.

SB052-019 TITLE: Robust Communications

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: The objective is to prototype innovative concepts that lead to improved connectivity among and to Unmanned Combat Air System.

DESCRIPTION: The need to transfer information among, to and from Unmanned Combat Air Vehicles (UCAVs) is critical. These communications channels must be secure and offer a low probability of interception and or detection in order to compliment the inherently stealthy air vehicle attributes. UCAVs may operate in small groups and employ concepts of operations in which sensing may be distributed among the group. As such, inter nodal data rates need to support sensor data rates and connectivity must be assured. Data rates and access vary by scenario and phase of mission. Over-provisioning and planning for “worst case” scenarios are not the answer and are an egregious waste of resources. The separation among the UCAVs can be from meters to kilometers. The distilled processed sensor data may need to be relayed outside of the UCAV group either to another aircraft, a satellite or to the ground.

PHASE I: Determine needed characteristics for Lower Probability of Intercept/Lower Probability of Detection (LPI/LPD) intra and extra nodal communications links and networks. Propose candidate waveforms, features and modes to meet desired performance goals. Consider free space optical, radio frequency, and other transmission modalities.

PHASE II: Prototype innovative LPI/LPD/LPE networked communications concepts in a laboratory environment and quantify the attributes that give it utility for J-UCAS.

PHASE III DUAL USE APPLICATIONS: Innovative communications concepts will make their way into the commercial sector however, low probability of detection and intercept systems are seemingly a narrow niche market outside of military or government use.

REFERENCES:
1. Survivable Mobile Wireless Networks: Issues Challenges and Research Directions, Sterbentz, Krishnan, Hain, Jackson, Levin, Ramanathan, & Zao, BBN Technologies, Cambridge, MA WiSe'02 28 September 2002 Atlatnta, GA Proceedings.
2. Spread Spectrum Signal Design: LPE & AJ Systems, David L. Nicholson, Computer Science Press, Rockville, MD, 1988.

KEYWORDS: UAV, LPI, LPD, LPE, Robust Networked Communications.

SB052-020 TITLE: Chip-Scale Technologies for Giga-band Signals

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To demonstrate design technology and implementation of a new class of integrated circuits for ultra low power, extremely wide bandwidth ("Giga-band") signals that enable efficient data communications in deeply embedded applications.

DESCRIPTION: The fundamental Giga-band principle is that very short time domain pulses of electromagnetic energy can contain more information (i.e., signal bandwidth) while simultaneously dissipating lower power than narrowband approaches. These short pulses can contain most of the spectral frequencies that span over several Gigahertz of spectrum. Radio communication systems using Giga-band signals will not only be more efficient in use of the spectrum, but will also be more difficult to detect and jam. The consequences of this simple principle are nothing less than revolutionary. Multi gigabit-per-second radio communications, sensors and processing will enable a new generation of brilliant networks, self-aware wireless devices and secure military solutions. Conventional, narrowband (less than 10% instantaneous bandwidth) technologies have a well-developed set of tools, technologies, and architectures that are used throughout industry. This effort seeks to leverage the design and modeling tools that have been developed for narrowband systems, but for much wider bandwidth signaling paradigms, Giga-band signals. Based on the ability to transmit, receive, and decode very short pulses, the full exploitation of Giga-band technology requires a new set of circuit techniques for implementation at the chip-scale. This topic seeks innovative ideas on the implementation of new circuit techniques and approaches for integrated Giga-band chips. As examples, zero (or near zero) bias pulse amplifiers are needed to fully realize the power savings of Giga-band pulsed radio systems. Another example is the delay element. In most implementations, a Giga-band pulsed radio system will use delay lines in an analogous fashion to the banks of filters that are usually used in narrowband systems. On-chip, efficient, low dispersion delay lines will enable a host of design options, depending on their delay time and precision. A third example is pulse generation techniques. Pulses must be formed efficiently, without the need for current drawing large bias currents for nonlinear devices.

PHASE I: Perform a design study of these and other pulse-based building-block circuits and techniques within a framework of a working wide bandwidth radio system. Perform modeling and simulation of design. Tradeoffs between power and relevant performance metrics should be studied as well as comparisons, parallels and dualities with narrowband radio systems. Complete final report on feasibility of implementing integrated circuits for Giga-band applications.

PHASE II: Complete the detailed design of appropriate integrated circuits for demonstrating the Giga-band principle. Fabricate the proposed Giga-band radio and demonstrate functionality in a test bed. Analyze performance across the relevant metrics developed in Phase 1.

PHASE III DUAL USE APPLICATIONS: Giga-band chips will enable multi gigabit-per-second radio communications, sensors and processing for both civilian and military platforms. In addition, a new generation of brilliant network gear, self-aware wireless devices and secure military solutions will also benefit from the availability of these chips and the Giga-band signaling paradigm. Power constrained devices may benefit the most, including wireless consumer products, and military devices such as unattended ground sensors.

REFERENCES:

1. Smith, Paul, ed. Ultra-Wideband, Short-Pulse Electromagnetics 5: Proceedings of the Fifth International Conference, Edinburgh, Scotland, Kluwer/Plenum Press, October 2002.
2. Taylor, James, ed. Ultra-Wideband RADAR Technology, New York, CRC Press, 2000.
3. Andrews, J.R., Fast pulse generator survey. Pp. 95-121 E.K. Miller (Ed.) Time-Domain Measurements in Electromagnetics, Van Nostrand Reinhold, New York, 1986.

KEYWORDS: Short Pulse, Wide Bandwidth Signals, Integrated Circuits.

SB052-021 TITLE: High-Speed Metallic Interconnects Technology

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Design, construct, and test low cost copper based high speed (>10 Gb/s per channel) electrical interconnects technologies for off-chip electrical interconnects.

DESCRIPTION: The on-chip clock rate of silicon microprocessors and other large-scale integrated circuits have been increasing with reduction in minimum feature size and could reach clock rates of 10 GHz in the next 3-5 years. Smaller scale integrated circuits have already been demonstrated with multi-GHz data rates. The performance of printed wiring board (PWB) technologies that provide chip-to-chip interconnections have increased at very modest rates as compared to the chips. For electrical interconnect technology, the primary limitations to implementing high-speed interconnections are frequency-dependent loss and high power dissipation. Creative silicon interfaces have been developed to compensate for the loss resulting from current passive interconnects. The silicon interfaces add complexity, cost and power to high-speed interfaces sending high frequency signals over current passive electrical interconnects. Next-generation advanced information processing systems, such as those expected to be used in real-time synthetic aperture radar imaging, automatic target recognition, and intensive medical image processing, will require large aggregate computational and communication bandwidths. Since most of these systems are assembled from multiprocessor, memory, and special-purpose digital signal processing chips, the ideal communication bandwidths between them need to be on the order of a Terabit/sec in order to handle the real-time, high-resolution and large images (such as those generated by a synthetic aperture radar (SAR) to be processed. Today, using conventional electronic off-chip wiring, the chips inherent speed cannot be fully utilized, and traditional electrical interconnect techniques utilizing conventional material system for example FR4-based Printed Circuit Board (PCB) are a limiting bottleneck in terms of speed, density, wiring length, cross talk and driving power [1] Materials such as alumina, GTEK, etc., that meet these requirements traditionally have been priced much higher than conventional FR4 boards. Optical interconnections are anticipated to alleviate this problem in the off-chip interconnects. However, optical interconnect techniques remain costly, dissipate considerable power, and are still far beyond the present in practical application in most PWB technologies. This topic seeks proposals to develop new interconnect technologies that support bandwidths that rival optical technologies. Of interest is demonstration of new and innovative metallic based interconnect technologies with conventional PWB substrate materials that clearly enables electronic interconnections with higher connectivity bandwidths in cost-effective manners.

PHASE I: Demonstrate through modeling and simulation the performance of proposed interconnect technology. As appropriate, implement test fixtures and samples that confirm performance. Perform a study of potential applications of the high speed interconnect and quantify metrics for gauging the technology.

PHASE II: Develop, evaluate and demonstrate ability to fabricate optimized interconnect architectures for chip-to-chip signals. Evaluate and demonstrate prototypes with multiple chips attached. Develop bridge/switch fabric prototype chips to demonstrate potential architectures that benefit from high speed interconnections.

PHASE III DUAL USE APPLICATIONS: A number of dual-use applications could be enabled by this technology, such as high speed imaging systems and high performance computers. Military applications include high resolution radar and hyperspectral imaging systems. Other commercial applications include game machine and other high speed networking systems, such as the high-speed router, network switch connections, etc.

REFERENCES:
1. "R04003 high frequency material insertion loss comparison with other material types"—Report R02.9.7, released from Roger Corp.

KEYWORDS: Electronic Interconnect, Printed Wiring Board, High Speed Interconnects.

SB052-022 TITLE: Integration Technology for Trustable Integrated Circuits

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

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

DESCRIPTION: This topic seeks innovative approaches for the creation of fully trusted integrated circuits based on ability to implement novel assemblies of trusted and/or non-trusted sub components. Robust methods for attaining trusted functionality are of interest for advanced microelectronics intended for defense applications. Advanced microelectronic components such as full custom integrated circuits, application-specific integrated circuits (ASIC's), field programmable gate arrays (FPGA's), and systems-on-chip (SoC's) are critical parts of future weapons and defense systems. Such circuits are vital to the functionality and performance of modern DoD systems. It is essential that those integrated circuits be trustworthy or the performance, functionality, or mission of a system could be compromised. The objective of this topic is to develop enabling trusted assembly, integration, and test technologies that verify the correctness, reliability, and functionality of designed Integrated Circuits (IC's), i.e., approaches that enable IC users to fully trust the ICs they employ. In general, the technologies and approaches developed under this topic will be used to ensure IC's for DoD applications are trustworthy. Of particular interest are new assembly techniques, integration approaches, or embedded tools that provide non-destructive actions and offer the widest coverage of trust issues. In addition, innovative circuit design coupled with novel integration technologies that enable trust by employing combinations of multiple IC's, where known-trustworthy IC's ("trust engines") might be used to check the operation of other IC's of varying levels of trust are of interest. In addition, clever techniques to physically separate and spread functions among a few IC's such that it would be impossible for introduction of surreptitious circuits. Also, methods of ensuring trusted functions for field-programmable devices from third parties are of interest, including, for example, applying an advanced circuit like a trust engines as an appliqué on a general programmable fabric, or use of robust state variable encryption and novel memories to store circuit interconnect values. In these cases, dynamic performance and power dissipation might be of concern and should be addressed. Also of potential interest are methods to prevent reverse-engineering of IC's, provided the issues of ensuring IC trustworthiness are also addressed.

PHASE I: Complete a feasibility study of the approach being offered. This study should include a complete description of the technique/tool, and an analysis of the degree of trust it brings to IC users. Provide an analysis of any performance, reliability, or other limitations or vulnerabilities that may arise as a result of the offered approach. Define and perform experiments or analyses to quantify metrics for IC trustworthiness. In all cases, the offeror should clearly define the plans for implementing the technology and for establishing trust in its implementation.

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

PHASE III DUAL USE APPLICATIONS: Many commercial and industrial users of IC's now demand trustworthiness in function and operation for those components. Technologies that can be applied as appliqués or add-ons during integration would greatly simplify the ability to ascertain trust and would have commercial applications in a variety of areas.

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

SB052-023 TITLE: <u>Sensors for Wide-Area Measurement of Chemical Warfare Agents/Biological Warfare Agents Surface Contamination</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

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

OBJECTIVE: Identify and develop revolutionary technology to rapidly and quantitatively measure the wide-area surface concentration of active Chemical Warfare Agents/Biological Warfare Agents CWA/BWA following an attack using these agents and to determine the ratio of active/inactive agent following decontamination operations. The technology must be faster and more accurate than current state-of-the-art approaches. Furthermore, the capability to deploy the technology outdoors on the battlefield or indoors for building applications is a key objective.

DESCRIPTION: The release of a biological agent (Bacillus anthracis, or anthrax) by the mail attacks of 2001 resulted in wide area contamination in the Hart Senate Office Building and in the mail facilities through which the anthrax-laden letters passed. It is likely that even wider area contamination would result from larger scale CWA/BWA attacks on the battlefield. The decontamination efforts from the anthrax letter attacks took much longer and were much more costly due, to a large extent, to the absence of a rapid, wide-area surface agent detection system that could determine the locations of major surface contamination and measure the efficacy of the decontamination treatments in near real time. Furthermore, it is likely that the impact on military operations resulting from the use of these agents on the battlefield would be deeply impacted by the lack of a wide area surface detector.

Thus, there is an urgent need for revolutionary detection technologies to dramatically improve surface agent contamination measurements. The surface CWA/BWA detection system must provide a wide-area (preferably non-contacting) measurement of the surface concentration of active agent and the ratio of active/inactive forms of the agent faster (preferably near real-time) and with better accuracy than the current "swab and analyze" approaches. A broadband system that could detect and quantify all agents would be highly desirable, but more limited approaches that target classes of agents or even single agents could be operationally useful, and will be considered.

PHASE I: Identify and develop a detection methodology for wide area surface contamination measurements that is sensitive to the active and inactive forms of CWA and BWA. Prepare a feasibility study which will demonstrate proof-of-principle through analysis and/or laboratory experimentation with properly chosen CWA/BWA simulants to show performance advantages over current "swab and analyze" approaches.

PHASE II: Develop the novel surface detection technology and use simulants to characterize the detection performance including the surface detection sensitivity and the capability to discriminate small amounts of active agent from a large background of inactive agent. Incorporate the technology into a transportable system for testing with live agents at government-selected facilities.

PHASE III DUAL USE APPLICATIONS: The resulting technology will have significant dual use benefits, including integration into decontamination systems for military battlefield operations, and for systems to decontaminate military, commercial, and residential buildings following chemical/biological attack.

REFERENCES:
1. Centers for Disease Control and Prevention. Evaluation of Bacillus anthracis contamination inside the Brentwood Mail Processing and Distribution Center B District of Columbia, October 2001. MMWR Morb Mortal Wkly Rep 2001:50:1129–33.
2. Capitol Hill Anthrax Incident: EPA's Cleanup Was Successful; Opportunities Exist to Enhance Contract Oversight. GAO-03-686, June 4.
3. Sanderson WT, Hein MJ, Taylor L, Curwin BD, Kinnes GM, Seitz TA, et al. Surface sampling methods for Bacillus anthracis spore contamination. Emerg Infect Dis [serial online] 2002 Oct [date cited];8. Available from: URL: http://www.cdc.gov/ncidod/EID/vol8no10/02-0382.htm.

KEYWORDS: CWA/BWA Surface Detection, CWA/BWA Decontamination, Chemical/Biological Warfare/Terrorism Defense.

SB052-024 TITLE: Lightweight Solar-Regenerative Energy Storage

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop lightweight solar-regenerative energy storage technologies.

DESCRIPTION: The DoD is developing several near-space sensor and communications systems based on high altitude airships. These systems continuously require power for maintaining the airship position as well as for operating the sensor and communications systems. Some of these systems have on-station persistence goals of over a year, making it infeasible to rely solely on stored fuel. A solar-regenerative power system is desired to supply prime power during periods of typical system power draw. An example of such a solar-regenerative system is photo-voltaic cells combined with lithium-ion batteries. Winter nights may last 16 hours or more, forcing the overnight storage of at least 16 kW-hours for every kW of system power requirements. Given current battery technology (specific energy density of 0.5 kW-hr/kg) the energy storage subsystem would overwhelm the lift capacity of the airship. DARPA is seeking energy storage technologies with specific energy density at least 2.0 kW-hr/kg. The ideal technology is scalable to meet the power draw of specific systems. A power draw of 100 kW may be considered typical. The airship-based systems may include reserve fuel stores (e.g. hydrocarbons) to meet peak station-keeping power requirements during wind storms. The solar-regenerative system could be independent of a stored-fuel system, but integrated/synergistic approaches are preferred to reach the minimum total system weight.

PHASE I: Define a solar-regenerative power system approach and use analysis to quantify the specific energy density (kW-hr/kg) and total power system weight.

PHASE II: Develop a sub-scale laboratory demonstration of the complete power system, demonstrate the solar-regenerative cycle, measure round-trip efficiency, and use experimental results to validate the full-scale weight estimates. Identify manufacturing process development needed for production.

PHASE III DUAL USE APPLICATIONS: Lightweight solar-regenerative power systems are a key technology for a multitude of commercial and military applications. A majority of airship-based sensor concepts are military, but a majority of airship-based communications pseudo-satellite concepts are commercial. These power system technologies will also benefit satellites, both military and commercial. Additionally, the commercial cellular phone and hand-held electronic game industries are interested in increased operational periods using regenerative sources such as solar.

REFERENCES:
1. Gabriel A. Khoury, Airship Technology, Cambridge University Press, 1999, ISBN 0-521-43074-7 (particularly chapter 16, “Solar Power”).

KEYWORDS: Power; Battery; Fuel Cell; Energy Storage; Solar-Regenerative; Photo-Voltaic; Airship; Satellite; Manufacturing Processes.

SB052-025 TITLE: Bioluminescent Detection of Chemical Agent Contamination

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop a stable compact formulation of bacteria that bioluminescently detects chemical warfare agent contamination on surfaces.

DESCRIPTION: There is a real difficulty in detecting chemical agent contamination on the surfaces of buildings and equipment. Available methods for detecting these agents work well for gas or liquid phase contamination but not for contamination that has absorbed to surfaces. 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 producing a bioluminescent signal using the metabolites. The goal is to develop an easily field able, ready to use formulation containing the bacteria and the nutrients needed for initial culture that can then be self-sustained during detection. The “starter mix” of bacteria and media can potentially be lyophilized or compressed to achieve long term stability. Performance tasks include: Demonstrate detection of low volatility chemical agents such as O-Ethyl S-Diisopropylaminomethyl Methylphosphonothiolate (VX), determine time for degradation, and demonstrate stability of the dried material in harsh environments.

PHASE I: Demonstrate detection of low volatility chemical agent simulants on building materials 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 detect chemical agent contaminations in field conditions, and detection efficiency.

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

REFERENCES:
1. Use of a new rapid bioluminescence method for screening organophosphate and N-Methylcarbamate insecticides in processed baby foods. Saul SJ.
2. Zomer E, Puopolo D, Charm SE.J Food Prot. 1996 Mar;59(3):306-11.
3. Pholasin chemiluminescence detects mostly superoxide anion released from activated human neutrophils. Muller T, Davies EV, Campbell AK. J Biolumin Chemilumin. 1989 Jul-Sep;3(3):105-13.

KEYWORDS: Bacteria, Chemical Warfare Agent, Contamination, Metabolize, Culture, Polution.

SB052-026 TITLE: Novel Propulsion Using Humphrey Cycle or Other Concepts

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Space Platforms, Weapons

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

OBJECTIVE: Develop and demonstrate novel engines that use the Humphrey thermodynamic cycle or other novel energy conversion approaches, and which produce lower levels of vibration than pulse detonation or piston-crank embodiments. The long range objective is to develop a new propulsion technology base that can achieve efficiencies above 40% while achieving the environmental cleanliness, power to weight ratios, and low vibration of today's turbo-machine engines

DESCRIPTION: The Humphrey cycle is a thermodynamic cycle that combines the best features of Otto (internal combustion engine) and Brayton (turbo engine) thermodynamic cycles. The Humphrey cycle includes constant volume combustion (CVC) like that found in a piston-crank or Wankel engine as well as full working gas expansion like that found in a turbo-engine. As a result of greater ideal thermodynamic efficiency, Humphrey cycle based engines promise significant improvements in efficiency and power production. The most commonly suggested implementation of a Humphrey cycle is as a pulse detonated engine1 (PDE) or with the addition of a wave rotor2, 3 pressure exchanger. Although studied for decades, these implementations have proven to have limitations that are preventing their transition from the laboratory. An approximate Humphrey cycle implementation using a piston-crank engine is commonly called a Miller cycle engine. Miller cycle engines are being successfully used in marine engines and special transportation applications; however, Miller engines have the same vibration, weight, fuel restrictions, and complexity issues that limit piston-crank engines in comparison to turbo-shaft engines. This topic principally seeks to stimulated and develop Humphrey cycle engines, other then PDE, Wave Rotor, or Piston-Crank engines, that have the full efficiency promise of the cycle and achieve the high power to weight ratios, low-vibration, environmental cleanliness, and fuel flexibility typical of turbo-engines. It is also open to other propulsion or engine concepts which may provide similar advantages in practical implementation. Since it is imagined that this engine would have wide application to transportation power there are many military and commercial missions that can take advantage of this more efficient and functional engine. The risk associated with this project is the potential difficulty to achieve smooth combustion and continuous operation of this engine across a range of fuel air mixtures and engine speeds. In addition, a successful engine must have the feature of good mechanical balance that will allow low vibration with no major impact to power performance. Finally, the engine must have projected power to weight figures that are competitive with today's best turbo-shaft engines.

PHASE I: Prepare a feasibility study to characterize the advantages of the proposed type engine concept. The study should focus on measuring basic thermodynamic characteristics that will validate and quantify the proposed concept. Provide a list of technology improvements needed to make the approach practical/feasible.

PHASE II: Develop a prototype of the proposed engine concept and perform extensive testing of its performance and operating characteristics.

PHASE III DUAL USE APPLICATIONS: There are a wide range of transportation and stationary power applications that can benefit from a high efficiency Humphrey cycle engine. Since it is imagined that this engine would have wide application to transportation power there are many military and commercial missions that can take advantage of this more efficient and functional engine. Any benefit in fuel economy or flight performance that can be achieved for military application is likely to also have a similar benefit in civilian applications.

REFERENCES:
1. Bussing, Pappas, "Pulse Detonation Engine theory and concepts," AIAA Progress in Aeronautics and Astronautics, 1995.
2. Wilson, J., and Paxson, D. E., "Jet Engine Perfomance Enhancement Through The Use of a Wave-Rotor Topping Cycle," NASA TM 4486, October, 1993.
3. http://www.grc.nasa.gov/WWW/cdtb/projects/waverotor/index.html.
4. http://www.nationmaster.com/encyclopedia/Miller-cycle.

KEYWORDS: Reduced Fuel Consumption, Humphrey Cycle, and Constant Volume Combustion.

SB052-027 TITLE: <u>Wavelength Conversion of Pulsed Fiber Lasers</u>

TECHNOLOGY AREAS: Sensors, Weapons

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

OBJECTIVE: Develop efficient nonlinear optical wavelength conversion technologies to generate mid-infrared wavelengths for infrared countermeasures from pulsed fiber lasers.

DESCRIPTION: Recent advancements in optical fiber laser technologies have shown that efficient fiber based lasers can provide a 1 or 1.5 micron pulsed output with nanosecond type pulse widths. The feasibility of using fiber lasers to pump optical parametric oscillators to generate 2-5 micron wavelengths has been demonstrated but, to date, their application to military systems have had limited success due to nonlinear effects caused by the high peak power in the optical fiber. A further problem is that conventional fiber lasers operate in a continuous wave mode or pulsed fiber lasers often have long cavity lifetimes limiting such laser's ability to generate advanced waveforms applicable to infrared countermeasures (IRCM). Innovations are sought that can make fiber based laser technologies applicable to IRCM applications by developing efficient wavelength conversion and generation of flexible temporal waveforms. The potential payoff in tactical applications of fiber based laser technologies is the promise of an all in-line fiber optic laser eliminating problems associated with thermal-mechanical misalignment of discrete optics used in conventional military lasers.

PHASE I: Prepare a feasibility study to demonstrate efficient wavelength conversion of a near infrared pulsed fiber laser into the mid-infrared (2-5 micron) as an in-line wavelength converter component.

PHASE II: Develop, test and deliver a prototype mid-infrared laser providing full-scale hardware demonstration of the proposed technology. Hardware should be capable of use in field tests or limited environment flight tests.

PHASE III DUAL USE APPLICATIONS: Demonstrated technology may be inserted into future IRCM Preplanned Product Improvement (P3I) program efforts. Some of the laser components that are anticipated to be used in IRCM systems have commercial applications in materials processing systems and medical diagnostics equipment.

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1. 1. Klein, M., Adel, P., Auerbach, M., et al., "Microsecond pulsed optical parametric oscillator pumped by Q-switch fiber laser", Opt Lett. 2003 Nov 15; 28(22):2222-4.
2. Gross, P., Klein, M., Walde, T., Boller, K., et al., "Fiber laser pumped continuously-wave singly resonant optical parametric oscillator", Opt Lett. 2002 Mar 15;27(6):418-420.
3. Britton, P., Taverer, K., Puech, D., et al., "Optical parametric oscillation in periodically poled lithium niobate driven by a diode-pumped Q-switched erbium fiber laser", Opt Lett 1998 Apr 15; 23(8);582-4.

KEYWORDS: Mid-Infrared, Pulsed Fiber Laser, Wavelength Conversion.

SB052-028 TITLE: <u>Autonomous Operation of Hovering/Staring Fixed Wing Unmanned Aerial Vehicle</u>

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Design and develop a fixed wing Unmanned Aerial Vehicle (UAV) that can be commanded to hover or perform station keeping at a fixed vehicle attitude to stare at an object.

DESCRIPTON: Hovering/staring fixed wing UAVs would offer a unique capability to the warfighter, since it enables potentially long stare modes while maintaining a dash capability to avoid enemy fire. Recently, hobbyists have demonstrated under manual control of remotely piloted fixed wing vehicles that depending on engine thrust to weight ratios, vehicle stall characteristics and flight control capability that hovering/staring is possible with fixed wing UAVs to reasonable level of tolerance.

PHASE I: Systems studies to identify requirements for performance studies to size concepts and identify technology and design requirements. Develop innovative flight control algorithms and avionic designs for enhancing the control performance of fixed wing UAVs to enable them to hover at high angles of attack. Demonstrate by detailed Six Degrees of Freedom (6-DOF) simulations the ability to hover near stall. Quantify sensor accuracies, aerodynamic performance and engine thrust resolution required to achieve robust hovering performance of representative fixed wing UAVs. In addition, quantify anticipated fuel consumption usage for candidate UAVs using conventional two-stroke combustion engines or electric motor prop driven UAVs for various stare times. Conduct necessary laboratory and wind tunnel tests to help develop robust control algorithms.

PHASE II: A target application will be identified. A proof-of-concept model for this application will be designed and constructed for limited demonstration. This model need only be sized and constructed in a manner that provides a realistic demonstration that will justify future investment. Demonstrate hovering performance on a fixed wing UAV. Quantify jitter performance based on commercial-off-the-shelf (COT) video cameras commonly used for UAV applications. Demonstrate ability to stare at a known target for approximately 30 seconds to 2 minutes. Quantify in-flight performance of long duration stares on a candidate UAV. Demonstrate vehicle control via autonomous operation.

PHASE III DUAL USE APPLICATIONS: There are a number of military and commercial applications to increase the ability of fixed wing UAVs to provide persistent Intelligence Surveillance and Reconnaissance (ISR) capability while maintaining rapid dash speeds. In the military sector an agile maneuvering air vehicle that can stare at a target to improve identification would provide great utility. In the commercial sector, such an approach would also enhance the operation of civilian UAVs including traffic monitoring, border patrol and homeland security.

REFERENCES:
1. Reynolds, O., "The Soaring of Birds," Nature, Vol. XXVII, p. 534.
2. Wilson, J. A., "Sweeping Flight and Soaring by Albatrosses," Nature, Vol. 257, p. 307.

KEYWORDS: Autonomous, Staring, Perching, UAV, Persistent ISR.

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