DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

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

DARPA has identified technical topics to which small businesses may respond in the second fiscal year (FY) 99 solicitation (99.2). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included, followed by full topic descriptions. The topics originated from DARPA technical program managers.

Please note that **5 copies** of each proposal must be mailed or hand-carried; DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

It is expected that the majority of DARPA Phase I awards will be Firm Fixed Price contracts. Phase I proposals **shall not exceed $99,000**. DARPA Phase II proposals must be invited by the respective Phase I technical monitor (with the exception of Fast Track Phase II proposals – see Section 4.5 of this solicitation). DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should not exceed $750,000. It is expected that a majority of the Phase II contracts will be Firm Fixed Price-Level of Effort or Cost Plus Fixed Fee.

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 1-800-334-3414 or internet: http://ccr.edi.disa.mil. The small business **MUST** also have a Commercial & Government Entity (CAGE) Code. This code is part of the CCR registration package. For information call 1-888-352-9333 (Press 3) or 1-888-227-2423 or internet: www.ccr.dlsc.dla.mil.

The responsibility for implementing DARPA's SBIR Program rests with the Administration and Small Business Directorate (ASBD). The DARPA SBIR Program Manager is Ms. Connie Jacobs. DARPA invites the small business community to send proposals directly to DARPA at the following address:

DARPA/ASBD/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714

(703) 526-4170
Home Page http://www.darpa.mil

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

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. 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 fund no proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

In order to ensure an expeditious award, cost proposals will be considered to be binding for a period of 180 days from the closing date of this solicitation. For contractual purposes, proposals submitted to DARPA should include a statement of work which does not contain proprietary information. Successful offerors will be expected to begin work no later than 28 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.

To encourage the transition of SBIR research into DoD Systems, DARPA has implemented a Phase II Enhancement policy. Under this policy DARPA will provide a phase II company with additional phase II SBIR funding if the company can match the additional SBIR funds with non-SBIR funds from DoD core-mission funds or the private sector; or at the discretion of the DARPA Program Manager. DARPA will generally provide the additional Phase II funds by modifying the Phase II contract.

On a pilot basis, the DoD SBIR Program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. DARPA encourages Fast Track Applications between the 5th and 6th month of the Phase I effort. Technical dialogue with DARPA Program Managers is encouraged to ensure research continuity during the interim period and Phase II. 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 not exceed $40,000.

DARPA 1999 Phase I SBIR
Checklist

1) Proposal Format

   a. Cover Sheet - Appendix A (identify topic number) ______

   b. Project Summary - Appendix B ______

   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 (see Appendix C of this Solicitation) ______

   n. Company Commercialization Report - Appendix E ______

2) Bindings

   a. Staple proposals in upper left-hand corner. ______

   b. **Do not** use a cover. ______

   c. **Do not** use special bindings. ______

3) Page Limitation

   a. Total for each proposal is 25 pages inclusive of cost proposal and resumes. ______

   b. Beyond the 25 page limit do not send appendices, attachments and/or additional references. ______

   c. Company Commercialization Report (Appendix E) is not included in the page count. ______

4) Submission Requirement for Each Proposal

   a. Original proposal, including signed Appendices A and B ______

   b. Four photocopies of original proposal, including signed Appendices A, B and E. ______

INDEX OF DARPA FY99.2 TOPICS

SUBJECT/WORD INDEX TO THE DARPA FY99.2 TOPICS

DARPA 99.2 TOPIC DESCRIPTIONS

DARPA SB992-032 TITLE: Low Cost, Miniature Energy Storage and Management Devices

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: To develop an innovative, miniature, robust energy storage and management system for supplying multiple voltage levels to miniature sensor suites.

DESCRIPTION: Modular suites of micro-sensors for health monitoring of missiles/weapon systems (emphasizing small size, low power consumption, and low cost for environmental conditions sensing) are under development. It is envisioned that the microelectromechanical systems (MEMS) devices will be capable of detecting and/or measuring real time extremes in temperature, humidity, shock, strain, and adverse chemical presence for early-warning health monitoring of missiles in their storage containers, as well as other applications. A major technology barrier to implementing new and innovative sensor technology, however, is energy storage and management. New and innovative techniques are needed to provide micro-batteries and smart energy sources for supplying various power levels to the sensing devices, and conserving and managing the energy supply for a 10 year shelf-life. Not only do power sources need to be miniaturized, made 'smart', and made to last ten years (at a low cost), they also need to be able to withstand and function under the harshest of military environments. Small, smart, robust energy sources are a must for the future of miniature systems and a great technological challenge.

PHASE I: Develop a detailed approach to the development of an energy source for accomplishing the stringent objectives of this project. Analytically and/or with prototype devices demonstrate the capability of the proposed technology(ies) that will provide miniaturized, low-cost, 'smart' power to MEMS sensing devices over harsh environments for 10 years. Define all theoretical limitations of, and any technological barriers to implementation of, your design (including such parameters as minimal size, maximum peak capacity, output capabilities at hot and cold temperatures, etc.) Provide example energy demand profiles that the devices will be able to meet. Describe the concept for interfacing or integrating the energy devices with miniature sensors.

PHASE II: Fabricate and demonstrate prototype miniature power sources. Develop 'smart' processing for the power sources (discharging, recharging, scavenging, etc.) Assuming a cyclic energy usage profile, test and develop specifications for the micro-battery devices.

PHASE III DUAL USE APPLICATIONS: The dual use potential of the product from this effort is phenomenal. A DOD study of the MEMS technology market released in 1995 anticipates markets within the next decade to approach $3 billion per year. MEMS sensor production is currently over $200 million per year. Micro-battery technology directly feeds that industry. It is believed that micro-battery usage by MEMS sensor users would be near 100 percent. Furthermore, miniaturization technologies among multiple engineering disciplines (spanning military, bio-medical, and industry) could benefit from and apply 'smart', miniature power technology.

KEYWORDS: Batteries, Micro-Batteries, MEMS, Power Supplies, Energy Scavengers, Smart Technologies

REFERENCES: Department of Defense, "Microelectromechanical Systems: A DoD Dual Use Technology Industrial Assessment," December 1995.

DARPA SB992-033 TITLE: Low-Cost, High-Speed, Efficient Generation of Communication Signals Using Chaotic Devices

KEY TECHNOLOGY AREA: Command, Control, and Communications

OBJECTIVE: Creation of a prototype device that uses a chaotic signal generator along with a controller that can be used to produce communication signal.

DESCRIPTION: Research and development leading to a prototype signal generation device that exploits the natural complexity of chaotic systems. Efforts need not focus on synchronization of chaotic transmitter/receiver pairs, rather on the generation of a controllable sequence of pulses intended for communication purposes. Prototype devices can be either electronic or optical and should have a natural frequency of at least one megahertz and be scalable, in principle, to gigahertz frequencies using existing technology. An evaluation of possible benefits of this technology in terms of practicality, cost, size, reliability, and energy efficiency will be required.

PHASE I: Construction of a megahertz frequency chaotic device and a controller capable of fast switching between unstable periodic orbits for the purpose of producing useful symbol sequences. Define the limits of scalability and quantify the expected benefits.

PHASE II: Produce a prototype capable of being used as a drop-in replacement for a new or existing application. Prototype along with complete documentation of test cases and results must be delivered.

PHASE III DUAL USE APPLICATIONS: Harnessing chaotic dynamics from simple systems could result in reduced device complexity for wireless communication systems. Device simplification would lead to possible improvements in cost, size, reliability, and energy efficiency. Such improvements would be especially important for portable communication devices such as pagers and cellular phones as well as devices used by soldiers and unmanned ground and aerial vehicles. Deep underwater optical repeaters, satellites, and other difficult to access devices would also highly benefit from a reduction in complexity and power requirements.

KEYWORDS: Chaos, Chaos Control, Chaos Communications, Symbolic Dynamics

DARPA SB992-034 TITLE: Acoustic Bandgap Materials and Devices

KEY TECHNOLOGY AREAS: Air Vehicles, Materials, Surface, Manufacturing

OBJECTIVE: Develop the modeling and processing capability to manufacture components with regions of acoustic mismatched impedance such that the vibrations within a specific frequency range are selectively and substantially reduced in amplitude.

DESCRIPTION: Acoustic scattering from impedance mismatched regions within a component can be used to reduce or enhance sound propagation at a given frequency depending on the characteristics of the material(s), the positional relationships of the scattering regions, and the resulting phase shifts. This topic is designed to exploit this phenomenon for the fabrication of acoustic bandgap materials and devices. Potential applications include quieting or vibration reduction in heavy equipment mounts for rotating machinery, races for angular contact bearings, or other areas of significant impact on Department of Defense needs. Experiments to quantify the benefits of components made from these novel materials as a function of frequency should be conducted along with suitable controls. It is important to compare the performance of devices manufactured with acoustic bandgap materials with that of conventionally fabricated components. Thus, bandgap materials for use above 5,000 Hz (where passive damping materials are of limited effectiveness) are of particular interest. In order to effectively reduce sound and/or vibrations, acoustic bandgap materials typically contain two- and three-dimensional internal structures of mixed materials. Thus, one approach to the fabrication of these components is through the use of solid freeform (SFF) manufacturing methods. Because SFF technologies are toolless (machines fabricate parts directly from digital representations), optimized components containing specific mixtures and locations of materials may be developed rapidly and affordably. For example, it is anticipated that the use of SFF equipment may play an important role in the fabrication of inserts for metal or polymer cast structures.

PHASE I: Design, fabricate and characterize an acoustic bandgap material with a relatively simple geometry (plate, bar or rod). Characterization to include damping behavior as a function of frequency.

PHASE II: Design, fabricate and characterize equipment mounts or bearing races using acoustic bandgap materials. Develop analytical and/or experience based models for the design of acoustic bandgap materials. Develop optimization methodologies for acoustic performance and validate with experiments. Cost models and a plan for commercial exploitation of the technology should be developed.

PHASE III DUAL USE APPLICATIONS: Acoustic bandgap materials are of interest in all areas where the control of excess sound or vibration is important. Military and civilian applications include equipment/motor mounts, bearing races, acoustic imaging array back planes, aircraft engine mounts, and avionics chassis. The potential improvement in performance (at relatively low cost) and the enhancements in the reliability of the resulting system (through fewer deleterious vibrations) make these devices attractive for further development in the private sector.

KEYWORDS: Acoustic Bandgap, Vibration Reduction Noise Reduction, Solid Freeform Manufacturing, Bearings.

REFERENCES:

1. "Theory of Acoustic Band Structure of Periodic Elastic Composites", M.S. Kushwaha, P. Halevi, and G. Martinez, L. Dobrzynski and B. Djafari-Rouhani; Physical Review B, Vol. 49, No. 4, Jan. 15, 1994, pgs. 2312-2323.
2. "Band-gap Engineering in Periodic Elastic Composites", M.S. Kushwaha and P. Halevi, Applied Physics Letters, Vol. 64, No. 9, Feb. 28, 1994, pgs. 1085-1087.
3. "Ultrasonic Band Gap in a Periodic Two-Dimensional Composite", F.R. Montero de Espinosa, E, Jimenez and M. Torres, Physical Review Letters, Vol. 80, No. 6, Feb. 9, 1994, pgs. 1208-1211.
4. "Sonic bands, bandgaps and defect states in layered structures-theory and experiment", R. James, S. Woodley, C. Dyer and V. Humphrey, Journal of Acoustical Society, Vol. 97, No. 4, April 1995, pgs. 2041-2047.
5. "Large Two Dimensional Sonic Band Gaps", F. Meseguer, Acoustical Society of America meeting in Norfolk, VA 1998. Web site for the article is: http://www.acoustics.org/136th/meseg2.htm.

DARPA SB992-035 TITLE: Biomolecular Electronic Materials and Devices

KEY TECHNOLOGY AREAS: Electronics, Materials, Sensors

OBJECTIVE: Develop and test biomolecular materials and processes for the creation of novel electronic, photonic and/or energy-conversion devices of interest to the military.

DESCRIPTION: The field of biomolecular electronics is focused on using biomolecules or their complexes (e.g., photosensitive proteins) for application as independent functional devices capable of interfacing with modern electronics. Typical examples include biosensors (proteins used for molecular recognition and catalysis), photoconverters, optical correlators, and optical data storage devices. Many of these devices are based on natural constructions and schemes; especially devices using light sensitive retinal protein complexes (a critical component in the human vision process). For example, retinal proteins, such as bacteriorhodopsin, promise to make possible high performance volumetric memory storage systems and artificial retina (image) sensors. Recent work demonstrated the possibility of building high-speed optical random access memory based on retinal proteins. These memory devices could offer storage densities in excess of 100 gigabytes/cc. Through this research we seek to develop biomolecular materials, processing, and fabrication methodologies that will allow for the construction of novel photonic, electronic and/or energy-conversion devices. Research should focus on those materials that can offer a significant improvement (revolutionary) in the area of optical (and/or electronic) image and data processing and storage, multi-spectral sensing, analog sensor fusion and energy conversion such as artificial photosynthesis. Interesting biomolecular material and device properties include: fault tolerance, defect-tolerance, energy efficiency, the ability to power from sunlight, self-healing, and system-level approaches to connection to other devices.

PHASE I: Synthesize biomolecular materials having the proper functionality needed for optical and/or electronic processing applications (stability, processing, diffraction efficiency, etc.). Sufficient characterization of these materials to indicate that their properties may exceed those of the materials currently used in purely abiotic devices, or offer functionalities not capable in abiotic materials.

PHASE II: Design, fabricate, and test optical and/or electronic components (sub-devices) based on biomolecular materials (developed under Phase I) that will demonstrate the utility and enhanced capability of these materials in an application of interest to the military or intelligence communities (e.g., high-density data or image storage, multi-spectral imaging or sensing, analog sensor fusion, etc.).

PHASE III DUAL USE APPLICATIONS: These materials may impact an array of systems (both military and commercial) requiring high speed optical processing, biosensors, vision capabilities and ultra-high density data and image storage. In addition, these biomolecular materials can be tailored, through protein engineering, to meet applications that are only barely envisioned at this time.

KEYWORDS: Biomolecular Electronics, Retinal Proteins, Artificial Retina, Biosensors, Optical Data Storage.

REFERENCES:

1. Vsevolodov, N.N., Biomolecular Electronics: An Introduction Via Photosensitive Proteins, Birkhauser, Boston, 1998
2. Joshua, J. and Ratner, M., Molecular Electronics: A 'Chemistry for the 21st Century' Monograph, Blackwell Science Inc., Boston, 1997.
3. Benys, J.M. "Biomimicry", William Morrow and Company, New York 1997.

DARPA SB992-036 TITLE: Direct Chemo-Mechanical Actuation

KEY TECHNOLOGY AREA: Surface/Undersurface Vehicles; Ground Vehicles

OBJECTIVE: Develop actuators capable of converting chemical energy directly into mechanical energy for applications involving autonomous robotic vehicles and/or lightweight devices to help humans augment their existing physical capabilities, e.g., human "exoskeletons."

DESCRIPTION: Autonomous machines like robots are often powered by electrical energy provided via batteries and/or solar arrays. While a variety of designs, architectures, and capabilities have been developed for these machines, most have very limited endurance and are, thus, of little military utility. Although needs for systems like combat-ready walking machines exist, significant electrical (battery) requirements often make them impractical from a logistics perspective. This results primarily from the low energy density of most batteries (<<500 Wh/kg). In contrast, hydrocarbon-based fuels have energy densities in excess of 10,000 Wh/kg, but their conversion to electricity via standard rotating machinery is relatively inefficient (typically much less than 20% in small sizes). Thus, this solicitation focuses on the design and proof-of-concept demonstration of a high-efficiency direct chemo-mechanical actuation system. This actuation system should be capable of producing large forces (1-40 N) over strokes ranging from 2-20 cm ideally with common hydrocarbon-based fuels. These actuators would allow, for example, for the development of long-range (5-20 km) walking machines or of an active "exoskeleton" to assist and enhance a soldier's locomotion and load bearing capabilities. Other applications for these devices that support DoD system needs are of interest as well. These chemo-mechanical actuators need to be controllable so that varying degrees of force may be obtained, possibly akin to conventional pneumatic actuators but without the need for a traditional compressor. One approach to obtain this controllability may be to regulate the amount of fuel consumed via mesoscale devices, smart material actuators, or even micro-electromechanical systems (MEMS) based components. Such devices should be able to properly control combustion/reaction processes, fuel/oxidizer mixing, and/or other elements of the system in order to achieve the desired level of force fidelity. A small amount of electrical energy for command and control may be necessary, but all mechanical work should be the result of direct chemo-mechanical transduction.

PHASE I: A preliminary/conceptual design for the actuator architecture will be developed and its feasibility will be demonstrated via analyses/modeling. A test of at least one critical component of the actuator system will be performed to prove the efficacy of the core ideas behind the device.

PHASE II: The actuator concept developed in Phase I will be applied to a complex machine such as a lightweight "exoskeleton" capable of augmenting the existing performance level of a human limb or an autonomous, multi-legged vehicle capable of "walking" at least 3.0 km. Integrated sensor feedback and control for the actuation system (s) should be included.

PHASE III DUAL USE APPLICATIONS: Actuators are crucial components throughout our industrial infrastructure. Numerous applications that utilize direct chemical-to-mechanical conversion concepts may be possible in areas ranging from construction equipment to pumps to field-portable equipment. A lightweight "exoskeleton" system capable of enhancing a soldier's mobility (endurance) and load bearing capability would be of interest to the military. Another area of interest would be machines capable of autonomous locomotion for long duration operations; these machines would be useful for intelligence gathering missions in a variety of battle scenarios and terrains.

KEYWORDS: Direct Chemo-Mechanical Actuation, Robotics, Exoskeletons, Actuators, Smart Materials, Controls

DARPA SB992-037 TITLE: Miniature Piezomotors

KEY TECHNOLOGY AREAS: Air Vehicles, Materials, Surface, Manufacturing

OBJECTIVE: Develop small-scale, piezoelectric motors that efficiently convert electrical energy directly to mechanical energy.

DESCRIPTION: There is a need for small (mesoscale), high efficiency electromechanical motors on the order of 0.1-10 cubic centimeters in size. At this scale, the energy density of piezoceramics and emerging single crystals piezoelectrics make these transducer materials attractive when compared to traditional electromagnetic devices. In order to develop efficient actuation systems, transduction elements need to be concurrently designed with driving power electronics, however. For example, the capacitive nature of the actuator's piezoelements should be tuned both electrically and mechanically to the same frequency in order to maximize the system efficiency (greater than 80%). A piezomotor must then find a way to drive the actuator in resonance while still achieving a controllable output. Other approaches to increase efficiency include schemes such as charge recovery in the driving amplifier. The power electronics design should constitute a significant part of the proposed effort. While numerous Coulombic drive piezomotors have been developed, novel designs that utilize genuine mechanical interference instead of friction are of particular interest. The precision typically generated in a Coulombic motor may be sacrificed to produce a high-speed device (10-50 msec time constants). Overall motor work output should be on the order of 1-10 watts and its efficiency and power density must exceed that of even the best electromechanical motors of comparable size.

PHASE I: A design for the mechanical and electrical portions of the actuator will be developed, including modeling adequate enough to infer that the performance of the device exceeds state-of-the art electromechanical motors. Preliminary electromechanical tests will be performed to examine and prove the fundamental concept of the device.

PHASE II: Working devices will be fully integrated with the power electronic system and electronic miniaturization will be pursued. The devices will be tested for efficiency, power, etc. in both terrestrial and space environment operations. The device will be specified for an application of interest to the military and/or intelligence communities and tested in situ.

PHASE III DUAL USE APPLICATIONS: The high cost of future space missions is driving our satellites and spacecraft to become ever smaller, yet actuators for the deployment of satellite subsystems, such as radiators, solar arrays or antennas, still rely on large, inefficient electromagnetic release mechanisms and motors. Small, efficient piezomotors are expected to enable more complex, reliable appendage articulation and deployments in a compact package. Aeroelastic and shape control of aircraft structures and small robotic actuation are other potential military and civilian applications of these motors. In addition, a distributed system of these active devices may permit accurate control of wings and engine inlets for enhanced flight capability (thus replacing heavy, costly, and inherently unreliable pneumatic controls).

KEYWORDS: Piezoelectrics, Smart Materials, Actuators, Motors, Electromechanics

REFERENCES:
1. Wallaschek, J., "Piezoelectric Ultrasonic Motors," Journal of Intelligent Material Systems and Structures, Vol. 6, Jan. 1995, pg. 71-83

2. Ueha, S., "Present State of the Art of Ultrasonic Motors," Journal Name Japanese Journal of Applied Physics, Vol. 28, 1989, Supplement 28-1, pg 3-6

DARPA SB992-038 TITLE: Terahertz (Thz) Device Technology

KEY TECHNOLOGY AREAS: Command & Control(C3), Electronics, Materials, Manufacturing, Modeling

OBJECTIVE: Development of solid state terahertz devices for operation in the range between 0.3 Thz to 10 Thz suitable for coherent sources and detectors for use in space-based and short range terrestrial communications, atmospheric sensing, and near object analysis.

DESCRIPTION: The electromagnetic spectrum from 300 Ghz to 10 Thz is scientifically rich but relatively technologically poor. The region represents a gap separating electronics, oriented towards transport, from photonics, oriented toward quantum transistors. Devices that mix quantum and transport physics will fill this void. The region offers the potential for a number of applications including space-based and short-range terrestrial or near earth communications, atmospheric sensing, collision avoidance for aircraft and ground vehicles, and near object observation and spectroscopy. To realize this potential the appropriate sources, detectors, and systems need to be developed. Innovative approaches are needed leading to the development, fabrication, and operation of coherent solid state terahertz sources. Efforts may include electrically excited devices as well as those driven by solid state optical lasers. Three terminal devices, and classical approaches, such as Gunn diode oscillators may be considered as long as proper power and efficiency advances are addressed. Highly desired are approaches in quantum wells and tunneling devices, as well as other novel quantum structure approaches. Desired are devices and device concepts that will deliver coherent radiation at potentially milliwatt power level, ultimately coupled efficiently in Thz circuits, guided wave structures and antennas. Work is needed in detectors to greatly improve the sensitivity, speed, and bandwidth. Specifically desired are efforts in semiconductor-based quantum well structures and the subsequent development of a useable detector that is narrow band, widely tunable, and yet highly sensitive. Other solid-state approaches may be considered. Approaches toward compact system modules addressing both generation and detection are also of interest.

PHASE I: Clearly demonstrate the feasibility of the proposed approach. Define the device that will deliver up to milliwatts of coherent radiation at specified frequencies in the Thz regime. And/or define the detector or detector structure detailing optimal geometry, bandwidth limitations, tunability, and current-carrying capacity. The definition of the device/ system-module needs to include principal of operation, material, processing, associated circuit or guided wave structure, and regime of operation.

PHASE II: Build upon Phase 1 work with a demonstration of system components and implementation of a prototype. Perform appropriate analysis and modeling, grow the material or structure, fabricate the device and test its performance.

PHASE III DUAL USE APPLICATIONS: Terahertz electronics and photonics have many potential applications. Covert communication on the battle field or in space, chemical agent detection, atmospheric environment sensing, near object detection, material imaging will benefit from new technology in this part of the electromagnetic spectrum. New terahertz electronics will also make possible ultra high speed signal processing.

KEYWORDS: Microelectronics, Photonics, Terahertz, Terahertz Electronics, Communications, Sensing, Heterojunctions, Quantum Wells, Semiconductors, Solid State, Sources, Detectors

DARPA SB992-039 TITLE: Very High Speed Atomic Force Microscope Imaging

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop an atomic force microscope based instrument for high-speed, large-field, imaging in the contact and intermittent-contact modes of operation.

DESCRIPTION: The atomic force microscope (AFM) is a compact non-invasive tool for the characterization of surfaces with significant amounts of relief. While the advantages of the AFM are well documented, it has one overriding drawback which has limited its use in DoD and commercial applications. This disadvantage is that only extremely slow scanning rates are possible. For example, state of the art performance is such that data acquisition rates are limited to ~300 Hz, i.e. a 256 by 256 image, over 50 um by 50 um square with several microns of topography, takes over four minutes. This SBIR seeks to sponsor the development of AFM type instrumentation to scan a 50 um by 50 um (or greater) field containing microns of relief at scan rates 1 to 2 orders of magnitude faster than this level of performance, i.e. about a second. The instrument should incorporate both contact and intermittent-contact mode operation with lateral and vertical position measurement accuracy in the nanometer range.

PHASE I: Define and analyze the approach to high-speed, large-field AFM imaging. Quantify the expected benefits and describe the limits of performance. Provide proof of concept demonstration of critical components.

PHASE II: Develop a high-speed, large-field AFM prototype with a sample translation capability. Demonstrate high speed AFM imaging in the contact and intermittent-contact modes on a variety of semiconductor and data storage samples.

PHASE III DUAL USE APPLICATIONS: Microelectronics is key to numerous DoD systems. Inspection and monitoring of critical levels is essential to maintain process control and yield. The AFM offers significant advantages over existing tooling as it provides true 3D surface characterization and metrology with nanometer scale accuracy without invasive and damaging incident radiation. DoD will benefit by having such tooling on its dedicated fabrication lines. In the commercial sector, improving the speed of the AFM without sacrificing its sensitivity would allow the use of the AFM where high-throughput is required such as microelectronics manufacturing, biotechnology and data storage manufacture.

KEYWORDS: Atomic Force Microscope, AFM, Imaging, Metrology, Inspection, Imaging, Proximal Probe, Contact, Intermittent Contact, 3D Imaging, Surfaces

DARPA SB992-040 TITLE: Computer-Assisted Modeling of Urban Environments

KEY TECHNOLOGY AREAS: Computing

OBJECTIVE: The objective is to design and develop an integrated geospatial data extraction workstation with capabilities to insert image understanding (IU) components for the automated extraction and three-dimensional (3D) representation of urban terrain (e.g., buildings, roads, vegetation, complex terrain) from digital space, airborne and/or terrestrial imagery.

DESCRIPTION: There is growing need for more cost-effective capabilities to generate 3D models of urban environments. Current operational capabilities are largely based on interactive photogrammetric, radargrammetric or computer-aided design (CAD) workstations. Algorithms to partially automate the extraction of urban features such as buildings, roads, vegetation and complex terrain are being developed and demonstrated in the image understanding (IU) research community. There is an opportunity to design and develop an advanced geospatial data extraction workstation that integrates the functionality of disparate photogrammetric, radargrammetric and CAD systems. The system would be capable of generating integrated geospatial models of urban environments (e.g., buildings that lie on the terrain, water runs downhill, cut-and-fill roadbeds, overpasses and undercrossings modeled with 3D topology). Interfaces to facilitate insertion of automated feature extraction components would enable incremental evolution of the system to support increasingly higher levels of automation. Specific goals towards these objectives include implementation of Application Program Interfaces (APIs) for the geometric modeling of disparate sensors, APIs for insertion of urban feature extraction components, and a mechanism for transmittal of derived complex 3D spatial data such as the Synthetic Environment Data Representation and Interchange Specification (SEDRIS).

PHASE I: Identify critical design issues for desired workstation and associated APIs. Refine concepts for integration of sensor model and image understanding components to meet system objectives. Conduct experiments to establish essential functionality. Specify targeted commercial and military applications. Deliver a specification, development plan, testing plan and cost estimate for the prototype system.

PHASE II: Implement the system and produce a functional prototype. Integrate at least one urban feature extraction algorithm. Demonstrate system performance in accordance with testing plan. Evaluate operating characteristics of the implemented system. Prepare marketing plan for targeted commercial and military applications.

PHASE III DUAL USE APPLICATIONS: Potential Phase III dual use applications lie in both defense and civilian applications for planning and execution of operations in urban environments. Military applications of increasing importance include force protection and military operations in urban terrain. Projected commercial growth areas for urban mapping include planning for the wireless communications industry and the security surveillance industry.

KEYWORDS: Photogrammetric Workstation, Radargrammetric Workstation, Interferometic Synthetic Aperture Radar, IFSAR, Image Understanding, Computer Vision, Digital Mapping, Urban Environments

REFERENCES:

1. DARPA Image Understanding Program Home Page (http://www.darpa.mil/iso/iu/)
2. SEDRIS Home Page (http://www.sedris.org/)

DARPA SB992-041 TITLE: Modeling The Terrorist Threat

KEY TECHNOLOGY AREAS: Modeling

OBJECTIVE: Develop a family of adaptive cognitive and behavioral models representing a terrorist organization's capabilities and vulnerabilities to support enhanced detection, assessment, and interdiction.

DESCRIPTION: To date there are at least twenty countries and over 400 organizations considered hostile to the United States and its allies. Increasing these countries and organizations to directly have or have access to weapons of mass destruction. As a result of this heightened threat, the United States strategy must increasingly focus on developing detection, assessment, and interdiction capability of the potential threat at the earliest possible time within the terrorist decision cycle. Research advances in area of cognitive and behavioral modeling offer potential enhancement to the predictive capability of these terrorist threats. However, there still remain some significant challenges to modeling the robust characteristics necessary to adequately represent and provide a predictive capability of an evolving organization in a dynamic environment such as terrorism and counter terrorism. Technology shortcomings include modeling of behavior moderators (ideology, cultural values, personality, etc), organizational dynamics and adaptive learning. In an effort to meet the objective of this SBIR, research may draw upon existing models, architectures, and techniques or create new ones. However, the approach should yield a significantly enhanced predictive capability in the following areas: early detection of potential threats; automated mapping of threat attributes and capability to potential targets; assessment of the potential target's vulnerability; assessment of the potential threat's vulnerability; and automated development of a range of recommended courses of action to support both force protection and interdiction.

PHASE I: In detail, conceptualize approaches for developing and validating a family of adaptive cognitive and behavioral models representing a terrorist organization's capabilities and vulnerabilities throughout its respective life-cycle, to include formation/emergence, fragmentation, reconstitution, and dissolution.

PHASE II: Create an implementation of the models to embody complete functionality of the components being demonstrated and validated. Provide complete documentation of test cases and results.

PHASE III DUAL USE APPLICATIONS: The development of organizational modeling algorithms and technologies will have a very strong commercial potential, to include a wide range of organizations and other social systems in both the private- (e.g., municipal planning) and public-sector (e.g., EPA response to hazardous materials incidents).

KEYWORDS: Cognitive Modeling, Behavior Modeling, Psychosocial Modeling, Decision-Making Modeling, Information Warfare, Information Dominance, Adaptive Learning, Adaptive Behavior.

DARPA SB992-042 TITLE: Human Interaction with Software Agents

KEY TECHNOLOGY AREAS: Computing

OBJECTIVE: Improve military information management systems for C4I applications through the development of tools that allow users to create, dispatch, steer, and control the performance of information agents, mobile code, and/or multi-agent software systems.

DESCRIPTION: This effort will conduct research and development leading to tools that enhance the abilities of users to interact with large information spaces and/or heterogeneous systems via the use of software agent technology. Efforts may address any aspect of agent-based computing for which significant leverage can be demonstrated; however, the area of human-computer interaction with agent-based code is of particular interest. Efforts should emphasize the creation of tools that enable users to create agent-based software, to dispatch the agent to do a search, query or other task, to determine the status of the agent, and/or to set preferences that "steer" the agent towards specific information sources or other resources.

PHASE I: Define the approach, and precisely explain the expected benefits of the system. Implement a feasibility demonstration of system functionality.

PHASE II: Design and build a prototype tool that embodies the approach, and show its performance on one or more demonstration of information management for military C4I systems. Complete documentation of test cases and results will be delivered.

PHASE III DUAL USE APPLICATIONS: Perform specific system demonstrations on end-to-end performance of the system on information management problems for military C4I. The development of agent-based software is a critical need in both military and industrial applications. This work will stress those current uses of agent-based codes that include information-seeking applications, user guidance and querying aid for large knowledge sources, and for other distributed information management and search applications. Better human-interaction tools for the programming and control of agents will enhance the military's ability to efficiently and rapidly find information on open-source and classified resources in support of both conventional and asymmetrical warfare. It will similarly allow non-government users to more efficiently find information in their large databases or on the Internet. In addition, the scaling of agent-based software appears to be a key enabler for e-commerce technologies that will allow significant cost savings in both the military and civilian sectors.

KEYWORDS: Agent-Based Computing, Human-Computer Interface, Distributed Information Sources, Information Agents, Integration of Information, Mobile Code.

REFERENCES:
1. US Air Force Science Advisory Board, "Information Management to Support the Warrior," 1999 - see http://web.fie.com/fedix/sab.html
2. J. Hendler, Intelligent Agents --- Where AI meets Information Technology, IEEE Expert , December, 1996

DARPA SB992-043 TITLE: Cyber Defense Situation Modeling

KEY TECHNOLOGY AREAS: Computing

OBJECTIVE: Development of techniques and tools for representing and assessing system status, readiness, potential attack circumstances, and defensive options to enable effective response.

DESCRIPTION: Research and development leading to techniques and tools that provide effective representation of the situation faced by a large system or application in relation to potential or ongoing information warfare attacks and its own ability to withstand such attacks to preserve its mission. Such techniques may either focus on performing computerized analysis or simply present relevant information in such a way as to significantly improve human ability to understand and assess the cyber defense situation. While efforts may address any technique for which significant leverage can be demonstrated, areas of particular interest include: abstraction of single host characteristics and detailed sensor data (e.g., from intrusion detection systems) to a higher conceptual level, representing application or mission impact; postulation and testing of hypotheses concerning attacker objectives; effective visual representations of cyber defense situation; modeling of system information flow and effects of disruptions; identification and selection of key system and application characteristics and information elements that best represent the current situation or serve as bellwethers for conditions of particular concern; modeling of defensive options and their impact on both attack progress and the system mission, including temporal elements; and adaptation of techniques from previous work in military situation awareness. Efforts may draw from existing methods, algorithms, or tools or create new ones, but in all cases proposals must clearly state what improvements are expected, for what ranges of system and application types, to what scale, for what types of attacks and under what conditions.

PHASE I: In detail, define the technique or approach to cyber defense situation representation and demonstrate its benefit through limited prototyping.

PHASE II: Create the full implementation of a tool that embodies the technique and validate its benefits for an actual large, mission-relevant system, using substantial data sets, by experiment, simulation, or case studies.

PHASE III DUAL USE APPLICATIONS: The development of effective models and representation of system defensive state against potential and actual attacks is important for Internet service providers, large distributed commercial enterprises, and critical infrastructure organizations. This type of capability will help lead to the ability to weigh overall effectiveness of options for reacting to developing attack situations, which should have significant dual-use applicability to the kinds of organizations noted.

KEYWORDS: Information Warfare, Situation Awareness, Security, Attack Modeling, Intrusion Detection and Response, Visualization, Indications and Warning

DARPA SB992-044 TITLE: Technologies to Support Real-Time Human Immersive Environments

KEY TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop algorithms and other computational techniques that reduce processing and telecommunication loads for technologies that can achieve "virtual" teleportation of humans for Remote Human-Human Interfaces (RHHI) and Remote Human Computer Interfaces (RHCI).

DESCRIPTION: Recent advances in 3D video pixelization of remote environments and 3D immersive air-acoustic sound fields make concepts for "virtual" teleportation feasible for prescribed scenarios at a cost of highly intensive preprocessed computations of the "virtual" field. Such capability make it possible to envision fully dynamic "virtual worlds" where humans can join together in collaborative environments with other humans and/or machine data representations for sharing data and conveying decisions. In such environments, the distinction between real and projected representations of human forms and graphical displays and decision aids is lost, thereby enabling true collaboration and data transfer without hardware. The removal of a prescribed and restrictive hardware environment provides flexibility for providing the most appropriate media channels and forms for transfer of information. Additionally, other biometrics measurements may be transmitted to enhance the quality of sensation required for conveying more realistic personal experiences of "physical" presence in a "virtual" world. However, achieving this level of real-time remote immersive environments probably requires several orders of magnitude speed-up in both the computations associated with the generation of the 3D visual-acoustic field and the transmission of data for remotely projecting the environment. Therefore, algorithmic methods are being sought to reduce these processing demands and communication loads.

PHASE I: In detail, conceptualize approaches for developing real-time RHHI and RHCI capabilities and method for sampling and conveying digitized biometrics measurements that convey sensory evidence of human presence. Phase I initiatives should demonstrate feasibility of achieving significant speed-up in computational and/or communication bandwidth reduction.

PHASE II: Create an implementation of algorithms that embodies complete functionality of the components being demonstrated, and validates performance and multi-scalability. Complete documentation of test cases and results must be delivered.

PHASE III DUAL USE APPLICATIONS: The development of such algorithms enables a new level of realism in collaborative environments for business, travel and leisure. These investments will further enhance the capabilities of interface systems to meet the process needs such as countering future military for providing direct interface between operational commanders and subordinate staff assigned with the execution of mission. Such applications will add to maintaining military and commercial superiority throughout the world.

KEYWORDS: Virtual Reality, Virtual Immersion, Teleportation, High Performance Computing, Data Compression, Biometrics Measurements, 3D Virtual Environments, Acoustic Signal Processing, Virtual Acoustic Environments, 3D Pixelization, Virtual Human Environments, Remote Human-Human Interfaces, Remote Human-Computer Interfaces.

DARPA SB992-045 TITLE: Handheld One-way Voice Communications System

KEY TECHNOLOGY AREAS: Computing

OBJECTIVE: To develop a handheld voice-to-voice one-way communications device capable of translating spoken English into another language.

DESCRIPTION: There is a need by the military and civilians to be able to communicate by voice in another language without the use of a human interpreter. While the concept of one-way voice-to-voice communications has been demonstrated, a robust and affordable system solution is needed. Moreover, until now a relatively powerful notebook computer with external microphone and speaker has been used; this configuration needs to follow industry trends and be implemented in a small, light weight configuration. The heart of the problem is system components that work for a wide range of minimally trained users. Work in text based machine translation indicates that a true two way speech translator is not feasible as an affordable product at present. The envisioned handheld one-way translation system will be simplified by focussing on domains like travel and crisis management, and will enable the user to easily conduct one-way voice communications in another language. System features should include: accurate translation of up to 2000 phrases for each task area; reliability and robustness; small size and weight; ease of use and training; ease of adding additional language translations and mission specific modules; and affordability in production quantities.

PHASE I: Develop a concept of operations and preliminary design. System components should include: hand held hardware (processor, storage, display, microphone, and speaker), application software, and phrase module database management.

PHASE II: Design, build and demonstrate engineering prototype system. Employ prototype system in operational scenarios and evaluate. Extensively stress test the system for two selected tasks such as crisis information interviewing, and common travel and navigation tasks in several languages including but not limited to Arabic, Mandarin, and Korean.

PHASE III DUAL USE APPLICATIONS: Identified military applications for this technology include special operations, medical interview, military training, check points, and ship boardings and inspections. Government applications include: use by police and firefighters directing or interviewing non English speakers in multicultural cities; U.S. Customs inspections; and humanitarian assistance. Commercial users include tourists and business travelers, and commercial aviation flight crews.

KEYWORDS: Voice Communications, Machine Translation, Translator.

DARPA SB992-046 TITLE: Stand-off Biosensors and Air-Motion Sensors

KEY TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: Development of unattended sensors which rapidly provide a sensitive and accurate warning of the presence and identity of biological threat agents at a distance of 1 km or greater, and which also measure air velocity.

DESCRIPTION: Biological agents, which may occur in many forms, e.g. bacteria, spores, viruses are extremely difficult to detect and classify, especially at longer ranges from the sensor (1-10 km). This solicitation requests novel sensor technologies (or improvements of existing sensor technology) which detect, locate, classify, and measure the level of all biological threats at stand-off ranges. Also desirable is the ability to measure air motion in 3-D, perhaps using the same sensor, and taking advantage of doppler effect and the sensor ability to measure range. Use of particulate measurement may provide a capability to measure airflow. The detection technology desired can be modified to have sensitivity against any new biological threat, and react without modifications to pathological variants of known agents. Ideally, the sensitivity should be an order of magnitude or more above that of a lethal/infectious dose for 10% of the population, but due to the stand-off nature of the sensor, considerably less sensitivity may be adequate. Use of multiple sensors to detect and track a cloud of agent, and predict its future path is desirable. The detector technology should be able to classify the agent and measure the threat density. The technology should support minimally attended operation, operation in the presence of interferants such as would be found in urban or battlefield situations, and provide a response in a few minutes or less, with low false alarm rate. A quantitative measurement of agent density is required. Small size is desirable. No known sensors currently available meet the above criteria. Understanding of the physical and biological processes that form the basis of detector operation is required, along with propagation prediction, and must be expressed through modeling of sensor behavior.

PHASE I: Design and demonstrate a laboratory prototype with sensitivity to a harmless agent or agents (simulants) which approximate a biological weapon(s), and validate modeling of performance.

PHASE II: Design and fabricate a laboratory prototype sensor which verifies performance quantitative models of sensitivity and false alarm characteristics against a variety of simulants.

PHASE III DUAL USE APPLICATIONS: The biological threat includes such agents as anthrax, plague, smallpox, and e-boli. These agents may be released inside or outside military/government facilities, and the response to protect life depends on rapid, reliable detection and classification of threat agents with very low false alarms. The civilian sector has a very similar threat environment due to terrorists who could take advantage of the very small quantities of agent required, and the difficulty of defense. The sensors developed may also have a much wider range of applications, including verification of Computational Fluid Dynamics code to predict air flow for building heating and cooling systems, and modeling of the intrusion of external irritants into a building.

KEYWORDS: Biological Defense, Biological Sensors, Stand-Off Biological Sensors, Sensors, Air Particle Counters, Meteorological Instruments.

DARPA SB992-047 TITLE: Wide-Area Terrain Mapping Using Ground Moving Target Indicator (GMTI) Radar

KEY TECHNOLOGY AREAS: Sensors

OBJECTIVE: Development of GMTI radar signal processing and image exploitation techniques to provide on-demand, near-real-time measurement of terrain elevation maps over very large areas.

DESCRIPTION: In standard GMTI radar operation ground clutter is purposefully filtered out using Doppler processing. However, many applications of GMTI, such as the military applications of tracking and targeting and civilian applications such as traffic monitoring and support to disaster relief, require accurate knowledge of terrain elevation and terrain feature positions (e.g. roads). While terrain elevation databases currently exist, the coverage is currently far from global. Other sensors which could potentially provide terrain survey information may not be available in a timely manner. Furthermore, even in regions for which these data exist, resolution varies, there are often bias errors in overall accuracy, and elevation and features may change over time due to natural (e.g. landslides) and human (e.g. construction) events. When GMTI Doppler filters are turned off, the result is a map of ground clutter return, showing all regions masked by terrain as shadowed areas. While GMTI resolution cells are coarse (e.g. Global Hawk GMTI resolution is approximately 10-m in range and 100-m in azimuth), GMTI radar provide repetitive coverage of potentially very large areas at very high revisit rates. It may be possible to take advantage of the rapidly changing geometry provided by these revisits to make estimates of terrain elevation very accurately registered to the sensor coordinate space by calculating the change in shadows with sensor geometry. This effect could be enhanced further by using any available terrain databases as a priori information in the calculation.

PHASE I: Develop and define in detail the mathematical and processing approach for real-time GMTI-based terrain elevation measurement for cases with and without a priori terrain elevation data. Demonstrate the capability non-real-time using simplified simulated data to be provided by the government.

PHASE II: Develop a real-time version of the algorithm developed under Phase I. Evaluate performance of the algorithm under a variety of conditions, including different terrain types, sensor parameters and geometry, and accuracy of a priori data.

PHASE III DUAL USE APPLICATIONS: There is a rapidly growing number of available GMTI radar, both military and civilian. On the military side, the Joint Surveillance Target Attack Radar System (JSTARS) is already operational and the Global Hawk Unmanned Aerial Vehicle (UAV) is in final development phases. On the civilian side, Raytheon sells the HISAR multi-mode radar with a GMTI mode, and the Canadian RadarSat II may include a GMTI mode. The growing availability of GMTI data make possible such dual-use applications as vehicle flow analysis for traffic monitoring and assessment of terrain conditions and trafficability during natural disasters. None of these techniques is possible without terrain data accurately registered in the radar's reference frame. The successful completion of this effort would facilitate these dual-use GMTI applications by providing these sensors to collect this type of registered terrain data in real-time without relying upon the availability of current, accurate databases or supplemental terrain mapping sensors.

KEYWORDS: Radar, GMTI, Terrain Registration, Doppler Processing, Image Processing, Terrain Feature Extraction.

DARPA SB992-048 TITLE: Active Spectral Sensors

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Development of scattering theory and material classification technology specific to active illumination to support the development of active spectral sensors.

DESCRIPTION: There is a proliferation of sensors and applications for passive multi- and hyper-spectral processing. These include military applications, such as the detection of camouflaged targets, and civilian applications, such as the characterization of terrain material properties. Any type of material classification application prefers to function in the visible to near-infrared (IR) region of the optical spectrum. However, for passive sensors this region is completely undetectable at night or in poor visibility conditions. For certain military applications, this problem has been somewhat alleviated by operating in the mid- and far-IR regions, but these give worse spatial resolution and much worse material classification capability. Furthermore, all passive techniques suffer from variations in illumination, target emissivity, and additional diurnal effects. One way to operate in the more beneficial visible to near-IR region while avoiding the above problems with variants is to illuminate the scene of interest actively with a tunable laser transmitter. Unfortunately such broadly tunable lasers are very difficult to build at practical energy levels for remote sensing, so it is desirable to identify first the optimal radiation bands. While much of this can be determined from existing spectral reflectivity databases, material phenomenology will be somewhat different because of the glint returns present in active sensing and the variation of glint properties with wavelength.

PHASE I: Develop a theoretical model to predict unique active illumination spectral phenomenology. Model should highlight the variation of optical scattering physics as a function of wavelength. Develop an initial design of spectral material classification based upon this model, with special emphasis on feature invariants resulting from active illumination. Determine optimal illumination bands based upon these initial studies as well as understanding of existing and near-term developmental laser sources.

PHASE II: Develop a laboratory test apparatus, including a broadly tunable laser illumination source, to evaluate theory developed in Phase I. Experimentally confirm phenomenology predictions. Fully develop active spectral material classification algorithms, and evaluate their performance using the laboratory test apparatus. Use this evaluation to produce the design for a fieldable active spectral sensor, including transmitter, receiver, and processing algorithms.

PHASE III DUAL USE APPLICATIONS: There is a current proliferation of applications for spectral technology. On the military side, such a sensor facilitates the detection and classification of camouflaged and otherwise hidden targets. Civilian applications focus on classification of terrain types and properties for mineral detection, environmental planning, and agriculture. Active capability permits the flexibility to execute these applications day or night, even in moderately poor weather conditions. Furthermore, the use of active illumination eliminates many of the variants common to passive illumination that degrade passive spectral robustness. The availability of potentially higher spatial resolutions as well as the added degrees of freedom of range and polarization provide the potential for great enhancements of baseline spectral capability.

KEYWORDS: Multi-Spectral, Hyper-Spectral, Active Spectral, Laser Radar, Ladar, Lidar, Tunable Lasers, Material Scattering Phenomenology, Material Classification.

DARPA SB992-049 TITLE: Autonomous Satellite Docking System

KEY TECHNOLOGY AREAS: Air Vehicles, Sensors

OBJECTIVE: Development of a precision autonomous satellite docking sensor and guidance system.

DESCRIPTION: Future unmanned satellites may evolve to require periodic servicing by low cost unmanned micro shuttles. What is envisioned in this topic is an end game sensor and navigation subsystem to allow precise and autonomous docking of the micro shuttle and the satellite to be serviced. An ideal solution would provide a supervisory, "man in the loop", yet fundamentally autonomous control system to provide regular low risk docking with suitably designed satellites. Simple docking mechanisms allowing less precise two body docking control are envisioned. Final docking sensors and guidance systems proposed efforts under this topic may address specific partial technology barriers and opportunities germane to ultimate vision, but must include system engineering efforts aimed at identifying remaining critical technology factors. Proposed efforts should encompass technology maturation through development and exercise of appropriate test items. Research areas of interest include but are not limited to precise automatic determination of the position and orientation of a complex three dimensiional body in space, automated control of a final approach trajectory in six dimensions, and effective use of a ground based human controller.

PHASE I: In detail, define the technology development to be undertaken and model expected operation. Conduct initial survey to scope system-level concept, define expected performance, and identify remaining technology issues.

PHASE II: Develop and exercise test items demonstrating critical technology issues. Complete system engineering definition and validate expected system-level performance. Develop approaches for addressing remaining technology issues.

PHASE III DUAL USE APPLICATIONS: Development of autonomous satellite servicing systems would have a wide range of uses in both the military and commercial arenas. Obvious applications in commercial markets include communications satellites, navigation satellites and potential for space station micro resupply. Military application would include surveillance and reconnaissance satellites as well as military communications satellites.

KEYWORDS: Reconnaissance Satellites, Electronic System Design, Sensors, Navigation, Autonomous Systems, Satellite Communications.

DARPA SB992-050 TITLE: Shape Shifting Portable Robots

KEY TECHNOLOGY AREAS: Surface

OBJECTIVE: This topic seeks to enable the development of portable robotic platforms that can change shape to gain access to denied areas and support Military Operations in Urban Terrain (MOUT) by functioning efficiently within confined spaces in urban environments.

DESCRIPTION: This effort will promote innovative research and development leading to adaptive re-configuration technologies that can be realized in portable reconnaissance systems. Efforts may address any innovative design that can provide mobile robots with an ability to vary their geometric alignment on any particular axis or combination of axes to adapt to confined space entry points (such as in collapsed buildings) and perform reconnaissance and rudimentary manipulation (push, pull, prod, etc.) tasks once inside.

PHASE I: Define the innovative approach in detail and describe enabling technologies that will address design and integration challenges associated with variable geometry such as adaptive materials, actuators, sensor arrangement, communications, power, etc. Present a basic design approach to the development of a portable (man-packable) shape shifting robot for use in confined spaces.

PHASE II: Design and build a functional shape-shifting robotic platform that is capable of penetrating a collapsed structure (to a distance of approximately 300 meters) and searching for trapped victims and hazardous materials inside. The system should provide 2 way audio and visual sensing modalities as a minimum. Additional payload capacity for chem/bio sensors is highly desired but not essential to the effort. System should strive for, but not be limited to a 4-hour mission duration and wireless communications where possible. Partial autonomy is desired in terms of fault tolerant navigation and severed communication recovery.

PHASE III DUAL USE APPLICATIONS: Portable robotic platforms have been envisioned as USAR (Urban Search and Rescue) assets since the SOFROB (Special Operations Robotics) and KNOBSAR (Knowledge Base for Search and Rescue) projects were initiated in 1994. Operational experience in the aftermath of the Oklahoma City Bombing and the Oakland Freeway Collapse (Northridge Earthquake) indicates that small shape shifting robots could be of enormous value in negotiating confined spaces in search of victims. Once found, victims could be further supported via transport of material (oxygen, medicine, water, food, etc.) via towed tubes, and human interface via 2 way speakers. Additional potential exists for applications in law enforcement, industrial inspection, confines space welding, shipbuilding, etc.

KEYWORDS: Robotics, Re-Configurable Mechanics, Artificial Intelligence, Computer Science, Electronic System Design, Reconnaissance, Surveillance, Target Acquisition, RSTA, Search and Rescue, SAR.

REFERENCES:

1. Blitch, J.G. and Maurer, R., 1996, "KNOBSAR: An Expert System for Robot Assisted Urban Search and Rescue", in Simulations Journal, June 1996.
2. Blitch, J.G. 1997, "Guise vs. Gadgets: The Case for SOF Overwatch in Robot Assisted Reconnaissance", in Proceedings of the 8th Annual Symposium for Special Operations and Low Intensity Conflict, Washington D.C., Feb 1997.