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 **41** technical topics, numbered **DARPA SB972-050** through **DARPA SB972-090**, to which small businesses may respond in the second fiscal year (FY) 97 solicitation (97.2). 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 offices.

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.

DARPA Phase I awards will be Firm Fixed Price contracts, **not to exceed $99,000**. DARPA Phase II proposals must be invited by the respective Phase I technical monitor. Phase II proposals are encouraged in the amount of $375,000 with additional funding available for optional tasks. The entire Phase II effort should not exceed $750,000.

The responsibility for implementing DARPA's SBIR Program rests with the Office of Administration and Small Business (OASB). 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/OASB/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 OASB and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based upon technical merit and the evaluation criteria contained in this solicitation document. 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) in question 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 30 days after contract award. For planning purposes, the contract award process is normally completed within 30 to 60 days from issuance of the selection notification letter to Phase I offerors.

DARPA 1997 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. Potential Post Applications ______

    i. Key Personnel, Resumes ______

    j. Facilities/Equipment ______

    k. Consultant ______

    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 FY97.2 TOPICS

DARPA SB972-077	Accelerating Network Protocols
DARPA SB972-078	Multilevel Performance Frameworks and Tools for High Performance Systems
DARPA SB972-079	Mobile Oceanographic Sensor Suite
DARPA SB972-080	Multi-Modal Interface for Command and Control of Military Robots
DARPA SB972-081	Tactical Grade Inertial Navigation System (INS) using Microelectromechanical Sensor (MEMS) Technology
DARPA SB972-082	Robotic Mechanisms Capable of Attaching Themselves to Moving Ground Vehicles
DARPA SB972-083	Man Portable Smoke Generator
DARPA SB972-084	Two-Dimensional In-Plane Thermal Deformation Measurement for Large Area Substrates
DARPA SB972-085	In-Situ Optical Fiber Stress Profilometer
DARPA SB972-086	Wideband Optical Receivers
DARPA SB972-087	Continuous Apertures
DARPA SB972-088	Technologies for the Detection and Characterization of Deeply Buried Targets
DARPA SB972-089	Instrumentation for Nanostructure Analysis
DARPA SB972-090	Spatial-Spectral Automatic Target Recognition (ATR)

SUBJECT/WORD INDEX TO THE DARPA FY97.2 TOPICS

DARPA 97.2 TOPIC DESCRIPTIONS

DARPA SB972-050 TITLE: Applications for Carbon Nanotubes

KEY TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Accelerate the transition of carbon nanotubes from the laboratory into reliable, reproducible, economical, commercial-scale products for military and civilian applications.

DESCRIPTION: Carbon nanotubes, with diameters on the order of nanometers and lengths from nanometers to microns, are currently being studied in laboratories around the world. The unique properties of these materials (high strength, lightweight, high surface area, uniform size, high electrical conductivity, etc.) imply a wide range of potential applications. For example, lightweight mechanical structures could be built out of extremely high strength carbon nanotube fibers and composites. Alternatively, the high surface area per unit volume and high electrical conductivity of carbon nanotubes hold out the promise of fabricating high surface area, porous substrates for chemical catalysts and energy storage devices. While several research groups have developed novel techniques to synthesize large quantities of these materials, "real world" applications based on the unique properties of carbon nanotubes have heretofore been lacking.

PHASE I: Identify and develop a useful application for carbon nanotubes based on one or more of the unique properties of this material. Justify the basis for the proposed application via consideration of performance, manufacturability, and affordability issues. Demonstrate feasibility by fabricating a prototype component and measuring its performance. Select a relevant military application for demonstration in Phase II.

PHASE II: Demonstrate the unique capabilities of the application proposed in Phase I. Evaluate its performance relative to a component fabricated using conventional materials. Specifically address technical feasibility, manufacturability, reproducibility, and affordability for process/product scale-up.

PHASE III DUAL USE APPLICATIONS: Commercial promise is based on the many unique properties of carbon nanotubes and could lead to the fabrication of, for example, high strength fibers and composites; high surface area catalyst supports; anodes for high energy density batteries; hydrogen storage devices; and lightweight, high conductivity wires. Potential military applications include: high strength, lightweight fibers and composites for aircraft structures, satellites, personal body armor, etc.; anode materials for high energy density batteries and ultracapacitors; hydrogen storage media for advanced power sources; radar absorbing media; and electromagnetic shielding materials. Commercial applications are quite similar and include: lightweight composites; batteries, capacitors and energy storage media; high surface area catalyst support materials; and ultralightweight electrical distribution wires.

DARPA SB972-051 TITLE: Energy Harvesting

KEY TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop and exploit energy harvesting concepts that can be used to replace batteries in small DoD and commercial devices.

DESCRIPTION: The environment offers a wide variety of energy sources that can be exploited to provide power on a continuous basis. Unfortunately, the specific power and intermittent nature of these sources presents a major challenge for their use. Many DoD and commercial applications have power requirements that fall within the range of energy harvesting, i.e., < 1 watt, for part of their duty cycle. Some of these systems require periodic power pulses on the order of 1-5 watts. While it may not be possible to generate power levels in this latter range using compact energy harvesting concepts alone, a systems approach that includes energy harvesting, storage, and conversion that is carefully matched to the required duty cycle could reduce or eliminate the need for conventional energy storage devices such as batteries. This approach would be highly valuable where battery replacement would impose too high of a logistics burden. While the obvious approach of solar photovoltaics combined with batteries is being exploited commercially and by the DoD, this solicitation seeks new approaches that reduce the size, increase the performance, or may not depend on solar energy as the energy source.

PHASE I: Develop integrated energy harvesting, energy storage, and power management concepts that would be capable of producing power in the 10's of milliwatts to 1 watt range for sustained periods and pulse capability to 5 watts. The system volume should be as small as possible (not to exceed 50 cubic centimeters). Select a relevant military application for demonstration in Phase II.

PHASE II: Demonstrate the energy harvesting/storage/power system as part of the military application selected in Phase I and evaluate its performance with respect to the traditional power source used for the application. Address the ability to manufacture these systems in high volume at low-cost.

PHASE III DUAL USE APPLICATIONS: Military applications of energy harvesting would include power for unattended ground sensors eliminating the need for battery replacement on the battlefield. This technology could be used commercially as a power source for embedded sensors in structures, e.g., bridges; airplanes; or to increase the endurance of consumer electronics, e.g., pagers; cellular phones.

DARPA SB972-052 TITLE: Materials for Frequency Adaptive Electronics

KEY TECHNOLOGY AREA: Materials, Processes and Structures; Electronics

OBJECTIVE: Develop thin and thick film materials and monolithic structures for frequency adaptable filters, antennas, oscillators, phase shifters, and other radio frequency (RF) devices utilizing the magnetic and electric field dependent properties of ferrites, ferroelectrics, and other novel oxides which can be tuned over an octave with overall loss tangents less than 0.001.

DESCRIPTION: The development of low loss ferrites, ferroelectrics, and other field adaptable oxide films will enable the development of a host of frequency agile filters, oscillators, antennas, and other RF devices that will have significant impact in reducing interference in secure communications e.g. SINCGARS, enhancing the frequency and beam steering agility of radar antennas while significantly reducing the size and complexity of conformal antennas for aircraft, missiles, miniature UAV's and satellites, etc. Efforts of interest will include both the development of processes for preparing very low loss tangent ferrites and ferroelectric films. Also of interest will be new oxide materials with enhanced dependence of the permitivity or permeability with electric or magnetic field respectively at low fields. Novel hybrid and monolithic structures and devices that can best utilize the frequency agility of these materials will also be considered.

PHASE I: In detail, define the process methodology for reducing the loss tangent in ferroelectric, ferrite, and other "tunable" materials or define novel device concepts that might circumvent the loss in existing materials. Preliminary tests of the proposed concept should be carried out.

PHASE II: Utilizing the process or device concept that was developed in Phase I, fabricate a functioning tunable component such as a filter, resonator or antenna element, and test it's properties, paying particular attention to the range of tunability and the effective quality factor.

PHASE III DUAL USE APPLICATIONS: Frequency agile filters, oscillators, and antennas could be included in the development of the next generation of broadband secure wireless communications that would have broad applicability throughout the three services. A Phase III program could develop the prototype of a frequency agile subsystem. Frequency agile RF technology will have a direct impact in commercial wireless telephony. The need for advanced signal conditioning in the next generation wireless communication systems will be severe because the number of networks and customers will be significantly enhanced over what it is today. The next generation military communication systems will also require this technology, thus, the opportunity for dual use.

DARPA SB972-053 TITLE: Novel Nanoelectronic Architectures

KEY TECHNOLOGY AREA: Command, Control and Communications (C3); Electronics; Materials, Processes and Structures; Modeling and Simulation

OBJECTIVE: Develop modeling and simulation tools for novel nanoscale devices which can be used as input to circuit simulators enabling novel device architecture for advanced microelectronics.

DESCRIPTION: Layered semiconductor materials and new fabrication techniques now permit nanometer scale electron devices with unique performance characteristics, i.e. Resonant Tunneling Devices and Single Electron Transistors and memories. Current directions in very large scale integration (VLSI) will be downscale limited frequency to less than 1 Gigahertz. Power dissipation will become a problem, both switching power and subthreshold or holding power. Complex interconnects will be an issue, i.e. interline capacitance and requirement for high conductivity in small wires and complexity in manufacturing. Cell area will not diminish accordingly because of need for large capacitance for static random access memory (SRAM) and dynamic random access memory (DRAM). Cache memory will be large and integrated locally to processor cells. It is expected that fabrication and testing costs will escalate.

Opportunities to address these problems rest with novel computer architectures based on ultrasmall devices. One approach is to use resonant tunneling devices (RTDs) in aggressively downscaled Digital Signal Processing. RTDs have promise for 100 Gigahertz operation [100 times complementary metal oxide semiconductor (CMOS)] and much lower power dissipation per gate (20 or more times smaller). Devices scale easily with the area of the vertical device. Memory elements of the same structure are possible.

PHASE I: Develop engineering models of devices and circuits with complexity to simulate and evaluate performance of a full circuit design, including adders, inverters, filters, analog-to-digital (A/D), etc. A/D concepts should be easily implemented in these devices as should memory devices formed in vertical geometries. Test designs based on limited 3-D integration are also desired.

PHASE II: The Phase II is essentially a continuation of the foundation laid in Phase I with more aggressive and detailed models and simulations, and full implementation into circuit simulators.

PHASE III DUAL USE APPLICATIONS: Continued microminiaturization makes inevitable the need to include quantum effects in chip design. The new class of devices based on quantum effects requires novel methods for their modeling. While the immediate market for such a package is within the research and development groups in industry, government, and universities, there is a potentially much larger market in the chip manufacturing industry. A powerful computational package will provide a major impetus to device design and subsequent subsystem development. Successful development of tools in Phase I & II will accelerate the development and military availability of high-speed, high-density, low-power electronics for processors in embedded and miniature systems, advanced digital radar, digital elint receivers, and secure, high data rate, digital networks.

DARPA SB972-054 TITLE: High Speed X-Y Stage with Sub 2.5 nm Accuracy

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a dramatically improved mechanical stage technology as specified by sub 2.5 nm accuracy, speed of 1 m/s and turnaround time of <100 ms.

DESCRIPTION: Research leading to the development of a mechanical stage, capable of supporting and scanning the area of a 12-inch silicon wafer, that exhibits true two-dimensional accuracy and high speed. Efforts should address the repeatability of positional monitoring (through turbulence corrected laser interferometers or otherwise), the conversion of repeatability to two-dimensional positional accuracy through the use, for example, of recently researched calibration procedures; novel drive mechanisms; novel approaches to lightweight and stiff construction; thermal management; and other technologies needed to achieve significant advances in speed, accuracy and fast reversal. In some applications operation in vacuum is required, in others operation at atmospheric pressure is required.

PHASE I: Experimental test bed to demonstrate proof-of-concept that may, for example, meet the speed and accuracy values over a small (e.g., 5 cm x 5 cm) area necessary to establish credibility for a full size system meeting specifications.

PHASE II: Demonstrate a full size system combined with an electron beam column (or other sub 100 nm read/write head) to generate patterns at the scan rates and positional accuracies specified. Vertical excursions should be compatible with the read/write head selected for demonstration.

PHASE III DUAL USE APPLICATIONS: Creating a high-speed (>3 cm 2/s) sub 100-nm patterning and inspection/metrology capability, with pattern placement accuracy a small fraction of the minimum feature size, is a major problem confronting the development of future electronic systems. Within the next several years industry is converting to 12-inch wafers, and high speed stage motion will be required to maintain the throughput requirement of 60 wafers/hour for lithography and related steps in processing. The annual market for wafer exposure tools is about one thousand units per year. From a military standpoint, improved accuracy of 2-D stages will lead to improved optoelectronic and optical devices (e.g., VLSI photonic Devices, networks, and systems) requiring true two-dimensional accuracy. Commercial applications include improved overlay of microelectronic and optoelectronic circuits resulting from improved accuracy of mask-making, and water exposure equipment.

DARPA SB972-055 TITLE: High Resolution Spatial Light Modulators with Beam Steering Capability

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Promote the development of high resolution spatial light modulators that will enable the efficient interconnection and distribution of optical signals between high density source pixel arrays and receiver pixel arrays. The capability for optical beam steering, in addition to amplitude modulation, is an important consideration for spatial light modulators for these applications.

DESCRIPTION: Developments of efficient arrays of light sources, especially Vertical Cavity Surface Emitting Lasers (VCSELs), are enabling new applications of optical interconnections in high performance information processing systems. For many of these applications the insertion of a spatial light modulator between the source array and the detector array can significantly enhance the functionality of the complete interconnect system, particularly when the modulator can provide dynamically reconfigurable beam steering or multi-casting functions. Innovative approaches to spatial light modulator are sought that incorporate features that take particular advantage of the unique properties of VCSELs, such as their high spatial coherence and wavelength control. Candidate technologies include liquid crystal as well as other electro-optical materials such as semiconductor multi quantum well and photorefractive materials. Anticipated systems applications include memory access and digital optical signal processing.

PHASE I: Develop proof-of-concept design either through fabrication of prototype components or by detailed modeling of designs based on demonstrated performance of existing components.

PHASE II: Develop and demonstrate a fully functional prototype capable of demonstrating critical functionality; provide design documentation for a full scale implementation.

PHASE III DUAL USE APPLICATIONS: The efficient, high resolution optical spatial light modulator, particularly with beam routing or multicasting capability, will enable a number of applications of smart pixel arrays and enhance the performance of optical signal processing systems. Military applications include optical two-dimensional array processors for target recognition, fast data base access, etc., and commercial applications include similar technology for image identification and page oriented signal processing.

DARPA SB972-056 TITLE: Arrays of High Sensitivity Optical Receivers

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Promote the development of optical receiver array technologies that will enable power efficient large arrays of smart pixels for use in digital optical signal processing systems.

DESCRIPTION: Research leading to innovative designs of light detector arrays and lower power receiver amplifiers will enable large arrays of receivers for optical interconnects exploiting recent advances in two-dimensional laser emitter arrays, particularly smart pixel arrays based on Vertical Cavity Surface Emitting Lasers. Improvements in laser design has resulted in sources with extremely low threshold currents to below 100 microamps. These reduced threshold power requirements for emitter arrays create the potential for low power, very high density arrays and for typical applications shifts the burden for further reduction of overall power requirements to the receiver array. Candidate technologies include detector designs that incorporate signal gain, such as avalanche photodetectors and semiconductor optical amplifiers, as well as schemes for implementing heterodyne detection or optical parametric amplification. Innovative approaches to implementing low power electronic amplifiers, such as wafer bonding of detectors for attachment to silicon electronics, are also of interest.

PHASE I: Develop proof-of-concept design, either through fabrication of prototype components, or by detailed modeling of designs based on demonstrated performance of existing components.

PHASE II: Develop and demonstrate a fully functional prototype capable of demonstrating critical functionality; provide design documentation for a full scale implementation.

PHASE III DUAL USE APPLICATIONS: Power efficient receiver arrays will enable a wide range of optical interconnect applications in high performance information processing systems, particularly in the form of two-dimensional arrays that can function with complimentary two-dimensional arrays of emitters. Military applications include optically interconnected processors for such applications as fast fourier transforms (FFTs), space time adaptive processors (STAPs), etc., and commercial applications include similar technology for interboard or intercabinet interconnections in high performance computing systems

DARPA SB972-057 TITLE: Nanoscale Lithography

KEY TECHNOLOGY AREA: Command, Control and Communications (C3)

OBJECTIVE: Develop integrated sensing for nanoprobe based lithography to enable advanced microelectronic structures and devices.

DESCRIPTION: It is recognized that scanned-probe lithography is a likely candidate for a viable nanoscale lithography. In order to obtain sufficient speed, cantilevers with integrated actuation and sensing appear the most viable route. Process development needs to be optimized. Development of more sensitive piezo sensing films is required, as is the appropriate control electronics and protocols.

PHASE I: Demonstrate for scanned probes the development of integrated sensing, for example an integrated optical detector using solid state wave guide and interference, or other forms of integrated detectors that do not have the present problem of low signal, high crosstalk with actuator signal and hence low sensitivity.

PHASE II: Choose most likely avenue and build a prototype cantilever with integrated sensor that satisfies needs for nanoscale lithography in terms of sensitivity and speed.

PHASE III DUAL USE APPLICATIONS: Possible applications include scanned probe microscopes, diamond turning and other micromachining, MEMS sensors, real-time vibration control, etc. From a military standpoint, this effort would make the appropriate processing tools available to industry for advanced microelectronics and nanoelectronics and the associated ultra small and ultra dense device structures. This would benefit the development of electronic devices operating beyond the current trends of silicon scaling, thus, enabling the development of devices of extremely high-density, high-speed, and low-power.

DARPA SB972-058 TITLE: Advanced Microelectronics Structures and Devices

KEY TECHNOLOGY AREA: Command, Control and Communications (C3)

OBJECTIVE: Develop electronic devices with critical feature sizes well below 50 nanometers to accelerate the development and military availability of high-speed, high-density, low-power electronics for processors in embedded and miniature systems, advanced digital radar, digital elint receivers, and secure, high data rate, digital networks.

DESCRIPTION: Recent advances in materials processing and fabrication techniques have made it possible to produce device structures with characteristic dimensions down to a few atomic layers. New classes of devices are emerging or being conceived. Many of these manifest quantum mechanical effects such as tunneling, quantum phase interference, or coherence. Proposals are invited addressing processing, fabrication, characterization and modeling of quantum devices. It is important that fundamental issues be addressed while concentrating on devices with realistic potential for DoD applications. Room temperature operation is sought. Particularly relevant are devices with possible low power and high frequency or high speed applications. In modeling efforts, proposals are encouraged that incorporate self-consistency, dissipation, as well as realistic boundary conditions. Material efforts are encouraged to explore heterojunction systems for silicon based nanoelectronics and to explore chemical self assembly for its potential in nanoelectronics.

PHASE I: Clearly demonstrate the feasibility of the proposed approach and its relevance toward processing, fabricating, and implementing sub-50 nm devices and circuits for enabling microelectronics beyond current trends in IC semiconductor technology. Clear indication needs to be given as to how the particular approach and concept will improve performance characteristics in speed, power, and/or density.

PHASE II: Build upon Phase I work and, ultimately, demonstrate the properties, characteristics, and performance of device structures and circuits in the nanometer regime (well below 50 nm). Performance should clearly address the benefits to DoD in the regime of power, speed, density, and increased functionality of advanced electronics; and how it will lead to substantially improved performance in Phase III plans for system insertion and application in such areas as digital radar, elint receivers, signal processing and electronics for communications networks. Successful proto-typing in Phase II would increase the probability of a Phase III.

PHASE III DUAL USE APPLICATIONS: Work could lead to new concepts in advanced electronic devices, new device architectures, terrascale integration, and could be the basis for high-frequency signal generation, high speed switching, and multi-valued data storage. Capabilities of new electronic products include completely integrated functionality, embedded signal processing, high speed data processing, and high bandwidth. As greater performance is required for many of these components, reduced device and system power requirements have become key issues in advanced electronic technologies. This focus area will accelerate the military availability of selected emerging technologies, emphasizing high performance at substantially reduced power and operating at room temperature. For example, development and military availability of very high speed asynchronous transfer mode switching capabilities and high data rate signal processing for radar receivers will be advanced under this dual-use low power electronics effort.

REFERENCES:
1) "The National Technology Roadmap for Semiconductors," published by the Semiconductor Industry Association (1994).
2) "High-Speed Semiconductor Devices," ed. by S. M. Sze, Wiley-Interscience Publication, 1990.
3) "Semiconductor Quantum Devices," by Marc Cahay and Supriyo Bandyopadhyay, Advances in Electronics and Electron Physics, Vol. 89, Academic Press (1994).

DARPA SB972-059 TITLE: Development of Ultradense Silicon-Based Hybrid Single-Electron Transistors/Field Effect Transistors (SET/FET) Memories

OBJECTIVE: To exploit advanced nanofabrication and simulation techniques to achieve the practical implementation of single cells of hybrid memories based on single electron devices combined with conventional devices which are capable of operating at room temperature.

DESCRIPTION: Recent achievements of nanofabrication technologies demonstrated silicon-based SETs with electron addition energies E_c as high as 80 meV. At the same time, theoretical studies have indicated a possibility to use hybrids of such SETs and nanoscale FETs for implementation of ultradense non-volatile bit-addressable dynamic random access memories (DRAMs) with sub-nanosecond cycle. In order to make these memories functional at room temperature, E_c of the SETs should be increased up to 250 meV, corresponding to the SET island size of 4-5 nm. Patterning on such scale is unavailable for most university groups.

The goal of this work is to exploit the advanced nanofabrication techniques developed in microelectronics and nanoelectronics to achieve the practical implementation of single cells of the hybrid SET/FET memories capable to operate at room temperature.

PHASE I: Clearly demonstrate the feasibility of the proposed approach and the relevance of implementing the SET/FET technology in the room temperature, sub-100 nm device regime. The work would include detailed modeling and simulation of the memories and demonstration of adequate nanofabrication techniques and characterization.

PHASE II: Build upon Phase I work with the subsequent fabrication of the cells and their experimental testing and characterization. If successful, the work would serve as a seed for a large-scale industrial effort toward implementation of hybrid terabit memory technology as the future successor of the current mainstream silicon DRAM/electronically erasable programmable read-only memory (EEPROM) industry.

PHASE III DUAL APPLICATIONS: The work would lead to new concepts in advanced electronic memory applications enabling massive memory, higher packing density, and low power at high performance. The technology would serve to impact multimedia, portable libraries, spatial data technologies, system-on-a-chip applications, and pattern recognition problems. The work would lead to new ultradense background-charge independent silicon-based room-temperature single-electron devices and circuits for future terabit digital circuits and systems. The ultra high density memory technology which would be enabled would lead to DoD mass storage applications in avionics, signal processing, and image processing.

DARPA SB972-060 TITLE: High Speed Analog to Digital Converter Technology

KEY TECHNOLOGY AREA: Electronic Warfare

OBJECTIVE: Design and development of devices and circuits suitable for incorporation into high performance analog to digital converters. Applications are to defense radar, communications, intelligence, and electronic warfare systems.

DESCRIPTION: Research and development of devices and circuits are sought which will enable the operation of analog to digital converters (ADCs) with performance beyond the capabilities of current commercial ADC technology. For example, the best commercially available electronic, semiconductor ADCs offer approximately 6-8 effective bits (ENOB) and less than 60 dB spurious free dynamic range (SFDR) at 1 gigasample/sec (GS/s) sampling rate. High sampling rate (1-100 GS/s), high resolution (16-6 ENOB) ADCs offer the possibility of minimizing or even eliminating analog components such as down converters in receiver subsystems, with consequent savings in size, weight and power, and advantages in flexibility, maintainability, and lower cost. One of the major barriers to improving converter performance is timing jitter. Optical or electro-optical devices or circuits which help overcome this limitation are, for example, of interest. Uncooled technology is preferred. If a cooled technology is proposed, the power, weight, and reliability implications should be clearly delineated.

PHASE I: Provide feasibility of proposed devices or circuits through analysis and/or preliminary fabrication and testing.

PHASE II: Perform detailed design, fabrication, and testing of devices or circuits. If funding permits, incorporate components into a complete ADC. Estimate or, preferably, measure ADC performance including nonlinearities or harmonic distortion described by parameters such as ENOB, and SFDR. Ideally, the electronic components of a hybrid converter should be integrated with multichip module packaging technology. Provide an analysis of the manufacturability of the proposed devices and circuits.

PHASE III DUAL USE APPLICATIONS: High performance ADCs have commercial potential in applications such as imaging and communications, and in military applications in radar and electro-optical signal processing.

DARPA SB972-061 TITLE: Mixed Technology Integration

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: To develop innovative materials, processes, and manufacturing techniques for integration of multiple, mixed component technologies within a single module (or package). Mixed technology modules are envisioned to be completely self-contained systems within a single module, such as an entire instrument.

DESCRIPTION: A mixed technology module contains the integration of two or more die with digital integrated circuits, analog and rf circuits, power electronics, discretes, passives, memory, microelectromechanical systems (MEMS) and structures, photonics, surface acoustics wave devices, as well as others, within a single enclosure (package). Of particular interest is the application of extensions from advanced packaging to the package-level integration of leading-edge digital/analog microelectronics with a multiplicity of die from other technologies, such as, but not limited to, MEMS, and power devices. In a mixed technology module, new demands may be placed on the package and interconnect, in that the package and interconnect is the intimate interface among multiple disparate technologies as well as the interface among multiple disparate technologies as well as the interface to the environment beyond the module. Each of the various technologies may present its own challenges for die attach, encapsulation, interconnection, all coupled with manufacturing and operational compatibility issues. At the module level, thermal management, differences in the coefficients of thermal expansion are expected to be key issues, as are maintaining compliance, die attach, and replacement and rework. Approaches that provide radical innovations such as simplification to the manufacturing process and assembly of the mixed technology modules should be geared toward eventual flexible, low volume access to manufacturing in a high volume environment using leading-edge processes. Generalized and applied approaches to calibrate, verify, test, and screen integrated mixed technology modules are also of interest. While the digital multi-chip module application is addressing known good die, a similar approach may be necessary to verify operation of other types of components, such as MEMS or photonics, to mitigate module yield issues. A method of accomplishing burn-in and test may be a critical issue for modules with multiple technologies. Simulation tools exploring manufacturability issues specific to aspects of mixed technology integration may improve yields and ultimately lead to first-pass success. Also of interest are packaging and interconnect technologies for mixed technologies intended for extreme applications, such as high temperature (above 250 degrees C), high power/high power density, wide temperature cycling range, harsh environment, limited spatial volume, etc...

PHASE I: Perform detailed analysis of proposed approach to verify feasibility of applying advanced packaging technologies for integration of multiple, mixed component technologies. Develop implementation plan including integration strategy and fully quantify the anticipated benefits. As appropriate, perform proof-of-concept experiments to confirm validity of approach. Fully detail transition plans to commercialize and transition technologies to widest use in industry.

PHASE II: Implement a detailed technical plan that fully develops a specific technology integration to result in the availability of new materials, tools, processes, capabilities, etc. for mixed technology integration.

PHASE III DUAL USE APPLICATIONS: Mixed technology modules have application in a variety of commercial applications, from embedded intelligent sensors, to smart power integrated circuits, communications, and global reckoning systems. Mixed technology modules would provide solutions to integrating component technologies that meet performance and reliability metrics, as well as minimizing package volume. Mixed technology modules will have application for global positioning and reckoning systems, intelligent sensors and actuators embedded in process equipment, instrumentation and intelligent sensors and actuators that meet very small volume and power requirements. Intelligent power switches for high current loads such as all electric vehicles, highly precise reckoning and positioning systems, integrated systems with minimal volume, and highly intelligent sensors for a variety of battlefield applications.

DARPA SB972-062 TITLE: <u>Materials, Simulation Models, and Tools for Fully Depleted Silicon-on-Insulator (SOI)</u>

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Development of new material, simulation, and device technologies that enable or support 100X reduction in dissipated electrical power as compared to conventional approaches in semiconductor technologies that would be demonstrated in 0.18 micron line width and below technology generation.

DESCRIPTION: Approaches to reducing electrical power dissipation include reducing power supply voltages by use of SOI materials with special device and circuit configurations and architectural organizations. In this particular effort, the greatest interest is in those technologies that support or lead to power supply reductions to the range of 0.9-1.2V. With conventional semiconductor technologies such as silicon CMOS, simply reducing the power supply voltage may also reduce the device operation speed, affecting performance. Those approaches that offer to provide parity or improvements in performance, without compromise to functionality or circuit integration density, and are compatible or at least integratable with existing process flows are of greatest interest. Near fully- and fully -depleted, thin-film SOI materials and device technologies are under development for such applications and efforts that further advance the state-of-art in these SOI technologies are of very high interest. In addition, new simulation or unit manufacturing tools that lead to or provide such revolutionary power reduction capabilities are also of potential interest. While present generation or near-term technologies are not excluded from consideration, the greatest potential opportunities are in those approaches that are applicable at and below 0.18μm minimum feature size and offer the greatest promise for integration in semiconductor fabrication facilities. Revolutionary new SOI material production or material characterization and qualification techniques are of very high interest as are material post-processes that may dramatically improve the quality of the thin silicon or buried oxide. Other areas of potential interest include, but are not necessarily limited to, first principles simulation models that couple new material and process manufacturing parameters to device and circuit parameters, modeling tools for the SOI structure that lead to material and device improvements, and new approaches to process integration that are inherently flexible and easily incorporate low power unit processes.

PHASE I: A detailed technical approach that fully describes the specific technology, its integration strategy and the anticipated benefits is desired. Fully quantify the expected costs and impact on water flow and throughput. As appropriate, provide plans on transitioning equipment/process technology/simulation tools to widest use in industry.

PHASE II: Execution of the technical approach developed in Phase I. For materials, a fully characterized, stable, repeatable process for fabrication of cost-effective, ULSI-quality substrates. For tools, a prototype chamber with demonstration of the process capabilities and extendibility to scaleable, manufacturing. Provide a strategy for completing commercialization and qualification of equipment. For simulation models, complete numerical or analytic implementation, verification, calibration, and integration into appropriate platforms or tool suites, with a demonstration of capabilities.

PHASE III DUAL USE APPLICATIONS: The development and availability of thin film, SOI materials and processes for design and production will lead to an expansion of the commercial markets for integrated circuits in low power applications. The growth rate of the low power segment of the commercial market is accelerating. Tools and technology developed in this program should find large demand from both captive and merchant producers of semiconductor integrated circuits. SOI technology will be part-for-part compatible with silicon/CMOS and will be able to replace any digital component. The SOI part will be much lower in power and higher in performance. Processors, memories, application specific integrated circuits, and full custom design will benefit from implementation in SOI from reduced power without compromised performance. Low power integrated circuits will be used in man portable electronic systems being designed for deployment in battlespace environments, including advanced digital radios and communications systems, personal information assistants, and embedded intelligent sensors.

DARPA SB972-063 TITLE: Programmable Exposure Sources for Maskless Lithography

KEY TECHNOLOGY AREA: Electronics; Manufacturing Science and Technology (MS&T); Materials, Processes, and Structures

OBJECTIVE: Develop electronically programmable exposure sources for maskless lithography for fabrication of microstructures, including advanced microelectronic devices and micromechanical structures.

DESCRIPTION: Emerging technologies can be exploited to develop lithography tools which generate the desired pattern electronically in real-time during the substrate exposure, thus eliminating the cost and time required for conventional mask tooling. The resulting programmable source will be an engine substitute for the source and mask configurations in conventional lithography tool designs. Innovation is required to simultaneously meet the demanding needs for pixel count, pixel size, and throughput. The approach should be compatible with the myriad other requirements of lithography systems which enable cost-effective manufacturing. Candidate exposure radiation sources include both photonic (optical, EUV, x-ray) and charged particles. Microelectronic applications should extend to design rules of 0.1 microns and below, with wafer exposure rates of tens of wafers/hour. Typical applications for micro-mechanical structures would address large areas (> 10 cm sq.) with geometries and depths of focus > 1 micron.

PHASE I: Conduct a detailed study of candidate approaches and preliminary experiments to support choices for Phase II effort.

PHASE II: The Phase II will include the fabrication, integration, and characterization of subsystem components to demonstrate effectiveness of the concept at the prototype level. To provide for insertion into the end-use lithography tool, the contractor should interact with potential tool suppliers on issues of compatibility between the source and the tool.

PHASE III DUAL USE APPLICATIONS: The developments will provide potential solutions in the key areas of microelectronics and micromechanical structures. Either area has a ready commercial market providing a strong “pull” for new technology developments. The developments of this program will provide significant benefits in both time and cost of new product developments. Similarly, these developments will enable cost-effective “low volume” production through reduction of non-recurring mask tooling costs. From a military standpoint, programmability in exposure sources eliminates the need for costly mask tooling, thereby providing cost-effective production of microelectronics at the low production volumes typical of military systems. From a civilian standpoint, programmability in exposure sources will reduce development time for new integrated circuits resulting in both cost savings and time-to-market for new electronic products.

DARPA SB972-064 TITLE: Imaging Materials and Processes for Microstructure Fabrication

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop new materials and processing to provide patterning for fabrication of microstructures, including advanced microelectronic devices and micromechanical structures.

DESCRIPTION: Innovative approaches are required to exploit opportunities in fabrication of new microelectronics and micromechanical structures. New materials are emerging which offer advantages in feature size and placement, increased tolerance in depth of focus, conductive resists, improved edge definition, and improved selectivity in new etch environments. Examples include inorganic resists, self-assembly materials, resist materials targeted for future exposure sources, and conductive resists. Processing innovations may include new tool applications and processing combinations which result in structures with some of the advantages listed above. Microelectronic applications are for design rules of 0.1 microns and below; typical applications for micromechanical structures would address large areas (> 10 cm sq.) with geometries and depths of focus > 1 micron.

PHASE I: Conduct a detailed study of candidate approaches and preliminary experiments to support choices for Phase II effort.

PHASE II: This effort will include the development and optimization of materials and processing, and the fabrication of appropriate device structures to demonstrate capabilities and to enable evaluation of developments.

PHASE III DUAL USE APPLICATIONS: The developments will provide potential solutions in the key areas of microelectronics and micromechanical structures. Either area has a ready commercial market providing a strong “pull” for new technology developments. The micromechanical structures area is a rapidly emerging technology, with new applications appearing across a broad spectrum of applications including such diverse areas as controls, sensing, robotics, etc. Microelectronics has an established presence in all facets of society, but its continued evolution is threatened because of reduced processing tolerances in the lithography area. From a military standpoint, new imaging materials will provide improved resolution and image placement, providing higher performance (e.g. frequency, low noise amplification, etc.) for microwave and millimeter wave circuits for use in radar, communications, electronic warfare, etc. From a civilian standpoint, the improved resolution and image placement from new imaging materials will improve operating speeds of microprocessors and digital signal processors, as well as increase the bit capacity of memory chips.

DARPA SB972-065 TITLE: High Speed Optical Memory Access

KEY TECHNOLOGY AREA: Command, Control and Communications (C3); Computing and Software; Electronics

OBJECTIVE: This program is aimed at developing and demonstrating technology to significantly enhance the throughput speed of optical memory access by exploiting recent developments in 2-D parallel access optical elements and recent developments in volume optical storage material. The focus of the program will be to develop and demonstrate prototypes of high speed parallel access to volume optical memory, including 2-photon and holographic. This capability will have high payoff to both military and commercial applications. The areas of primary interest are: A) development of optical I/O circuits; B) optical beam formation and deflection approaches; and, C) enhancements to volume optical storage media which will enable rapid read/write capability.

DESCRIPTION:

PHASE I: Rapid parallel memory access to read-only-memory (ROM), electronic or optical memory, where one may achieve the access speed of random-access-memory (RAM), but with Gbyte capacity; the Phase I portion would perform research and development into assessing the limits of parallel 2-D optical I/O throughput for both read and write, as well as assessing the tradeoffs of page versus bit serial access to volume optical storage. Of particular interest are the relative costs/benefits of various component options: optical emitter-based or modulator-based architectures; choice of holographic optical elements or micro or macro optical distribution schemes; the choice of detector elements in silicon or III-V material; the choice of packaging scheme for the optical to electronic integration, such as liftoff, fusion/thermal bonding, or bump bonding. Preliminary experimental concept demonstration of the capability of parallel access to enhance throughput are expected.

PHASE II: The Phase II effort will be an extension of the techniques developed in Phase I to develop and demonstrate a viable 2-D optical addressing and access system. It is important to demonstrate the potential of the approach to eventual scale up to full scale production and the high throughput optical input/output capability. DARPA expects the contractor to perform detailed tradeoff studies conducted up from each of the components to their respective architectures and systems. This approach will enable a thorough and informed basis for formulation and selection of the preferred component, architecture, and system. It is expected that critical components will be fabricated and a prototype demonstration of the complete sytem will be demonstrated.

PHASE III DUAL USE APPLICATIONS: Demonstration of the full potential of this technology promises to provide significant payoff in a very broad spectrum of information processing systems applications having major commercial and military significance. Fast access to stored terrain maps and intelligence will allow aircraft such as F-15,16 fighters to fly under all-weather, day/night conditions with radar off. Surveillance, reconnaissance, and intelligence communities of DoD all need rapid access to stored information. This SBIR impacts a broad range of military needs. Commercial applications include large data bases, and information storage and retrieval systems for banking, insurance, computer communication, and commercial avionic information systems. Leveraging of commercial digital video discs (DVD), optical discs, and commercial emerging 3-D optical storage systems, by developing parallel access techniques, are commercial technologies that potentially could be inserted into defense systems as a result of this SBIR project.

DARPA SB972-066 TITLE: Energy Scavenging for Personal, Portable Computing

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop alternative energy sources or energy conversion techniques to complement and/or supplement conventional battery and solar energy sources for worn and carried personal information products.

DESCRIPTION: Batteries are the primary energy source for computer and information products used by individuals engaged in productive work in remote locations. Battery technology is not keeping pace with the demands for increased computational complexity in wearable and carryable products used in field environments. Alternatives to conventional battery and solar energy sources obtained by scavenging energy from human energy sources, such as kinetic energy generated by the movement of extremities (legs, arms, fingers, etc.) or thermal energy dissipated by muscle contractions, and the subsequent conversion of these energies to enable the charging of batteries are sought. Also sought are innovative alternate methods to capture and convert energy from ancillary carried products. Examples of these might be conversion of kinetic and/or thermal energy obtained from firing a weapon or from miniature generators. Novel methods to obtain efficient energy conversion are also sought.

PHASE I: In detail, provide alternative energy source approaches, energy conversion mechanisms and efficiencies, methods to simultaneously utilize multiple energy sources, and battery charging approaches. Provide concepts, analyses and preliminary designs that show how the approach would provide enhanced energy utilization for a portable system.
PHASE II: Design and develop an energy scavenging system and demonstrate in a side-by-side comparison with a conventional, battery operated, portable electronic product.

PHASE III DUAL USE APPLICATIONS: Portable computing and information products such as laptop computers, personal digital assistants, and cellular phones can benefit from the use of complementary and/or supplementary energy sources to extend the time between battery changing or recharging. Alternative energy sources have strong applicability to individuals (military, industrial, commercial) that are engaged in productive work and are remotely located from conventional information resources. There is direct application to military programs like the Army's Land Warrior and 21st Century Land Warrior programs, as well as DARPA's Small Unit Operations program. In the industrial area, applications include supplying energy to information products used by individuals working in the field, i.e., electric utility, telephone linemen, firefighters, law enforcement, etc.

DARPA SB972-067 TITLE: Tools, Algorithms, and Sampling Techniques for Logistics Execution Monitoring Technology

KEY TECHNOLOGY AREA: Command, Control and Communications (C3)

OBJECTIVE: Develop logistics execution support algorithms and data sampling techniques that can provide real-time information to support the development of alerts and triggers for rapid logistics replanning processes.

DESCRIPTION: Research and development of technologies that support real-time visibility of assets in the logistics pipeline, and the infrastructure that support their conveyance, are needed to support the DARPA Advanced Logistics Program (ALP). Areas of interest include the development of "sentinels" that understand the explicit assumptions and expectations of plans, sample and interpret execution data, detect deviations, and trigger logistics replanning processes. Other important aspects include innovative and comprehensive methods for monitoring the execution space, including the condition of the infrastructure, as well as, assets in motion and in storage, and inexpensive labor free methods for aggregation and deaggregation of materials in flow. These solutions require advancement of multiple enabling technologies that support execution monitoring in a continuous replanning environment and their integration into an end-to-end system solution.
PHASE I: Define and evaluate algorithms that provide for the creation of plan sentinels" that capture expectations and assumptions of logistics plans and provides triggering logic to initiate replanning when deviation thresholds are detected. Investigate techniques and hierarchical system concepts involving active and passive tags that can be used to support visibility of real-time logistics flow, aggregation/deaggregation processes, and infrastructural state. Phase I efforts are focused at enabling technologies within DARPA ALP. Knowledge of the DARPA ALP system architecture will be required to facilitate integration during Phase II.
PHASE II: Integrate algorithms and sampling techniques into the system architecture being defined and developed as part of the DARPA ALP. Demonstrate the creation of sentinels" in support of a changing logistics support plan and replan triggers caused by disruptions of flow and/or loss of infrastructure. Demonstrate the potential for automated aggregation/deaggregation processing at critical nodes in the logistics pipeline.

PHASE III DUAL USE APPLICATIONS: From a military standpoint, this technology will provide improved capability to monitor force deployments; the distribution of material, supplies, and equipment; and the condition of infrastructure supporting logistics operations. Examples include tracking the movement of military transport aircraft, cargo ships, trucks, and trains, as well as the military equipment and supplies being transported. It will also provide the capability to monitor the condition of sea/aerial ports of embarkation/debarkation, road networks, and highway/rail facilities. This improved visibility will result in faster planning and replanning during contingency operations, and improve the day-to-day efficiency and effectiveness of the logistics pipeline. From a commercial standpoint, these advanced monitoring technologies have a direct application to commercial logistics-oriented operations. The greatest potential value is in areas related to "just-in-time" manufacturing, supply-chain management, inventory management, physical distribution, and the management of transportation carrier operations, i.e., rail, truck, ship, and aircraft operations. It also has the potential to improve carriers' abilities to provide real-time feedback to the customers on the status of their individual shipments.

DARPA SB972-068 TITLE: Multi-Platform Real-Time 3-D Visualization System Urban Environments and 3-D Terrain Imagery

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Create a cross-platform (PC, Mac, Sun, SGI, etc.) real-time 3-D visualization system capable of visualizing ultra-high resolution urban environments immersed in global unlimited 3-D terrain imagery simultaneously.

DESCRIPTION: Most high performance visualization systems are currently limited to high-end graphics deskside work stations costing in excess of $100K. The low-cost of high performance dedicated graphics hardware for personal computers and low-end work stations has made it possible to create a cross-platform system that can visualize virtually infinite amounts of high-resolution data in real-time. Along with the enabling hardware, a highly integrated software system that can effectively utilize the hardware with advanced graphics and data handling technologies needs to be developed. Today, this capability only exists on costly, difficult to use, and inflexible high-end systems. An advanced system is required to: 1) Visualize unlimited amounts of terrain and structure data in urban environments (e.g., large cities and military compounds containing complex structures) in real-time; 2) Implement state-of-the-art rendering and data processing techniques to provide the best possible performance for all types of data; and, 3) Run on a wide variety of systems ranging from high-end graphics work stations to standard PCs with dedicated graphics hardware.

PHASE I: Define the visualization system to be developed, requirements, software architecture, high-level design, technical approaches, tradeoffs, and enhancements over current approaches and existing tools. Demonstrate proof-of-concepts on at least two different graphics platforms.

PHASE II: Produce a prototype implementation of the system. Demonstrate capability on at least three different graphics platforms (high and low-end systems).

PHASE III DUAL USE APPLICATIONS: The emergence of low-cost 3-D hardware for the PC platform has made practical the application of 3-D terrain and building visualization technology to address a variety of problems such as building physical security analysis (counterterrorism), urban planning, forestry management, geographic information systems, and architectural visualization. This program could greatly enhance the capability of businesses (located abroad or in the United States) and government agencies to conduct analysis of threats from terrorism or crime and to assist them in taking prudent measures to reduce their risks of terrorist or criminal attack. Portable visualization of urban settings enables any user to view their organization/businesses in a manner useful to identifying risks from bombs, sniping, or other security threats, and taking appropriate protective measures

DARPA SB972-069 TITLE: <u>Continuous All-Source Region Monitoring</u>

KEY TECHNOLOGY AREA: Battlefield Awareness

OBJECTIVE: Combine all-source sensor data and operator-supplied activity knowledge into a continuous picture of events occurring among one or more sites of interest. Track vehicles, associate them with expected patterns of activity, and detect outliers and changes from normal patterns which may indicate illicit or aggressive behavior.

DESCRIPTION: Modern sensors provide a very flexible means to observe the battlespace. In particular, they allow around-the-clock scrutiny of high-interest sites (command posts, border crossings, facilities that may produce weapons of mass destruction) without the use of ground personnel. The purpose of this effort is to build an interactive inferencing system to support remote site monitoring.

The sensors of interest include radar (including MTI, HRR, and SAR modes), electro-optical (both IR and hyperspectral imaging sensors), SIGINT, and acoustics deployed both on airborne platforms and on unattended ground stations. The objects of interest consist of vehicles, people, and cargo. The activities of interest include transportation of goods, people, and vehicles; conversion of supply materials into products; and meetings among key people.

Well-established physical models exist to relate sensor reports to vehicle locations and movements. Fewer models exist for the activities which vehicles support, especially in third world cultures. Proposers to this topic should display knowledge of existing sensor, vehicle, and activity models, and propose ways for analysts to assist the inference process by posing their own hypotheses, models, or scoring criteria.

Conventional correlation and fusion systems adopt a policy of f using like-source data first (e.g., form MTI tracks, SAR groups, and SIGINT correlations separately), and then combining these intermediate products into an all-source picture. This topic solicits approaches that do not impose any artificial constraints on the processing chain. Rather, it seeks integrated algorithms that combine all sensor data together in order to maintain the most accurate, high-resolution estimate of vehicle movements, events, and activities.

PHASE I: Define an integrated tracking/activity analysis architecture. Specify algorithms to achieve each function. Identify potential users. Identify analyst and user interfaces. Recommend modalities and displays for each interface. Postulate operational scenarios faced by the potential users. Analyze the performance of the integrated system on those scenarios. Compare it to the performance of existing architectures. If substantial improvement exists, develop a top-level software design.

PHASE II: Complete software design, implement, and demonstrate continuous all-source monitoring to user community. Incorporate user feedback into an enhanced demonstration.

PHASE III DUAL USE APPLICATIONS: Pilferage affects many sites, from individual pharmacies to tropical hardwood logging concessions. Present-day site security systems rely on simple triggers and alarms which cannot detect pilferage during normal activities. While respecting various legal prerogatives, site surveillance systems that perform integrated tracking of individuals or vehicles can reduce theft and piracy. Monitoring of denied areas such as separation zones in a peace keeping operation or threat zones to enforce base security are two of many military applications.

DARPA SB972-070 TITLE: Innovative Approaches for Embedded Real-Time Ultra High Frequency/Very High Frequency (UHF/VHF) Synthetic Aperture Radar (SAR) Image Formation

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop innovative, efficient image formation algorithms for Foliage Penetrating SAR.

DESCRIPTION: High-resolution VHF/UHF SAR image formation is very challenging due to radio frequency interference (RFI) and due to the large integration angle and large fractional bandwidth. The large integration angle leads to severe range migration of the target during image formation. One computationally efficient algorithm is the Range Migration Algorithm [1], but this algorithm is very sensitive to off-track motion [2] and tends to require large computer memory and very large Fast Fourier Transforms (FFTs). Innovative hardware and software approaches for real-time onboard VHF/UHF processing are sought. Solutions must show potential improvement in cost, weight, power consumption, volume, processing speed, and/or image quality and must include or be able to accommodate known RFI mitigation techniques.

PHASE I: Perform algorithm and hardware designs, and parametric tradeoffs.

PHASE II: Develop, validate, and benchmark an image processor suitable for real-time operation on the appropriate platform.

PHASE III DUAL USE APPLICATIONS: Synthetic aperture radar imaging is finding ever-broadening application in military battlefield awareness and commercial mapping, land-use planning, civil engineering, and disaster assessment. The trend is to require foliage penetration and high resolution. Techniques to improve efficiency and quality of this technology would have great commercial potential.

REFERENCES:

1) Walter Carrara, Ron Goodman and Ron Majewski, "Spotlight Synthetic Aperture Radar, Signal Processing Algorithms", Artech House, Norwood MA, 1995.

2) Walter Carrarra, Sreenidhi Tummala, and Ron Goodman, "Motion Compensation Algorithms for Widebeam stripmap SAR,", in Algorithms for Synthetic Aperture Radar Imagery II, SPIE Vol. 2487, (D.A. Giglio Ed), (Orlando FL), SPIE, April 1995.

DARPA SB972-071 TITLE: Instrumented Sensor Suite for Controlled Imagery Acquisition

KEY TECHNOLOGY AREA: Computing and Software; Sensors

OBJECTIVE: Design, build, and demonstrate a prototype system to allow the acquisition of outdoor imagery under geometrically controlled conditions.

DESCRIPTION: The acquisition of metrically accurate imagery under field conditions is vital for an increasing variety of purposes such as collecting source imagery for the construction of three-dimensional models for visualization of militarily significant structures, for monitoring field tests of military hardware, and for acquiring data to be used for training and testing of automatic image processing algorithms under controlled circumstances. Photogrammetric techniques can be employed to measure scene characteristics, but work best when imagery has been carefully acquired using calibrated sensors. Present methods for acquiring such data are ad hoc, costly, and rarely satisfy the intended imagery needs.

The design and development of an instrumented sensor system suitable for employment on ground, and possibly also airborne, platforms is desired. The ideal system will be composed largely from commercial off the shelf (COTS) components and will be:

1) fully instrumented [using differential global positioning system (GPS), for example] to provide accurate, real-time position and orientation of the sensor and time of each acquisition;
2) composed of metrically accurate panchromatic, near and thermal infrared, as well as multispectral sensors;
3) capable of collecting individual frames or sequences at video rates;
4) calibrated for geometric and photometric accuracy;
5) mobile and able to operate outdoors under all weather conditions.

In addition, the prototype system would likely need to:

6) provide 10 gigabytes or more of local data storage;

7) include software to allow collection management and subsequent viewing and photogrammetric manipulation of collected data;

8) provide for easy dissemination of selected portions of the image archive including metadata in standard formats;

9) demonstrate feasibility of producing operational systems at low-cost.

PHASE I: Assess requirements for image acquisition from members of the synthetic environments and image understanding communities. Design a system that is capable of meeting those requirements to the maximum extent feasible. Analyze predicted performance. Deliver a specification and cost estimate for the ideal system.

PHASE II: Implement the system as designed. Demonstrate the performance by collecting data sets suitable for building three-dimensional models of buildings and other structures. Collect accurate ground truth data for each site through field surveys. Distribute data sets to interested users. Evaluate accuracy and operating characteristics of the implemented system.

PHASE III DUAL USE APPLICATIONS: There are many low-cost imaging devices for collecting imagery of the sort envisioned for the instrumented suite, but none combine metrically accurate sensors with high precision position and orientation data. The instrumented sensor has numerous applications for field data collection for accident investigation, architectural control, historical and archaeological archiving, and virtual reality modeling. The availability of instrumented sensor suites will not only fill an existing market for controlled image acquisition, but will also dramatically expand the market for analysis of visual data in many fields. Accurate geometric ground-truth data is vital for a variety of military purposes. Phase III application possibilities include construction of three-dimensional models for visualization of militarily significant structures, geometric reconstruction of field tests of military hardware, and acquisition of imagery and metadata to be used for training and testing of automatic image processing algorithms under controlled circumstances.

DARPA SB972-072 TITLE: Security Self-Checking Tools for the Global Command and Control System Leading Edge Services (GCCS-LES) Architecture

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop tools or mechanisms that provide the ability to probe, assess, and display the state of security and integrity of servers, applications, and data within the GCCS-LES architecture.

DESCRIPTION: Research and development is sought to enhance the security of the GCCS-LES architecture, which is being used for the Joint Task Force Advanced Technology Demonstration (JTF ATD), Joint Force Air Component Commander (JFACC) After Next Program, and other DARPA programs. Efforts may address self-probing of the system's security features and configuration, application and server status, and state of critical data objects. Self-probing tools must allow the ability to selectively control or shut down probes if the system state warrants it, and must protect themselves from unauthorized use or tampering. Tools must provide an appliation program interface (API) and should be pluggable into a common framework and graphical user interface (GUI). Approaches should be designed for scalability, extensibility to interoperate with new security features and tools, and evolvability as new or enhanced security APIs emerge. To the extent possible, approaches should be based on enhancing or extending commercially available security technology.

PHASE I: In detail, define the approach for self-probing, its semantics, design, functional and assurance approaches and limitations, and concepts for interoperation with commercial technology and extensibility. A tool API should be defined which fits into a common framework such as the one defined under DARPA SB972-078, "Open Architecture Security Tools."

PHASE II: Develop prototypes of one or more tools or approaches, and demonstrate them within the GCCS-LES architecture. Demonstration should include the ability of tool(s) to protect from unauthorized use and tampering. Experimentally evaluate their utility and benefits. Provide documentation of each tool or approach, including complete documentation of implementation results and test cases.

PHASE III DUAL USE APPLICATIONS: Tools for monitoring the health of a running system by continually probing its security and integrity should be of interest for many operational systems. The tools themselves have the potential to be commercialized as products. These tools will also be directly usable as part of a system security manager's toolkit in military systems such as the GCCS and in networks such as command center local area networks.

DARPA SB972-073 TITLE: Automated Synthetic Aperture Radar (SAR) Image Quality Assessment

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop, demonstrate, and evaluate techniques to automatically assess the quality of SAR images

DESCRIPTION: Advances in military and commercial SAR sensors have resulted in airborne and space-based systems that collect tremendous amounts of high-resolution detected SAR imagery that can be used for military surveillance and reconnaissance, as well as numerous commercial applications (terrain mapping, environmental monitoring, geological sensing, archeological investigations, etc.). The amount of data being collected from a single modern SAR platform far exceeds the capability for real-time review and assessment by humans; automated systems are being developed to collect, store, exploit, and disseminate SAR imagery. Unfortunately, system errors (e.g., calibration, hardware/software failures, communication errors, etc.) and processing errors (e.g., auxiliary data mismatch, mode mis-alignment, autofocusing, etc.) can result in the collection and automatic processing of SAR imagery that may be degraded, rendering it unsuitable for the additional processing stages. Without real-time image quality assessment the degradation in the SAR imagery could remain undetected for an unacceptable period of time resulting in expensive trouble shooting, missed collection opportunities, and expensive rerouting and re-tasking of sensor platforms. Fortunately, SAR systems are inherently coherent sensors and SAR image formation is a deterministic signal processing function; these features may provide the necessary information to allow the development of automated tools to assess the quality of SAR images. Quality features in the SAR image to be evaluated include, but are not limited to, dynamic range, contrast ratio, resolution, integrated sidelobe level, etc. This topic seeks proposals that will develop, demonstrate, and evaluate automated techniques to analyze the quality of formed SAR imagery in real-time, and provide a quality assessment of the imagery to guide follow-on processing, storage, and dissemination.

PHASE I: Design and develop a set of automated quality assessment tools that operate on SAR imagery and provide a real-time quality assessment of the formed imagery for follow-on processing.

PHASE II: Demonstrate proof-of-concept real-time SAR image quality assessment tool on collected SAR imagery. Provide a computational performance assessment which will allow for future extrapolation of the technique to images of various sizes and resolutions.

PHASE III DUAL USE APPLICATIONS: This technology is directly applicable to provide a valuable real-time quality assessment tool to support commercial airborne and space-based SAR imagery systems that perform terrain mapping, environmental monitoring, geological sensing, agricultural monitoring, and archeological investigations. This technology directly supports the military's requirements for the real-time exploitation of SAR imagery. Automatic SAR image quality assessment is required to ensure that future semi-automated and fully automated automatic target recognition (ATR) programs are processing useful data. Specific application platforms include the U-2, and the emerging Tier II+ Global Hawk and Tier III-Dark Star unmanned aerial vehicles

DARPA SB972-074 TITLE: Vehicle Motion Pattern Analysis

KEY TECHNOLOGY AREA: Sensors; Command, Control and Communications (C)

OBJECTIVE: Develop, demonstrate, and evaluate automated techniques for extracting purposeful temporal-spatial patterns from moving vehicle data.

DESCRIPTION: Detection of purposeful military movement is of critical importance to military decision-makers. Discernment of large, well-organized patterns in open spaces may be straightforward using conventional moving target indication (MTI) surveillance and reconnaissance sensors. However, detecting movement patterns of interest embedded within ambient traffic is far more difficult and is somewhat analogous to the engineering problem of extracting a signal from ambient noise. When a priori knowledge of the desired movement patterns is available, e.g., knowledge of doctrine or empirical movement data, then automated techniques similar to those used in signal processing or automatic target recognition may be exploited to detect the desired movement pattern; this is known as motion pattern analysis (MPA). The difficulty arises when a priori knowledge is limited, or non-existent, as will be the case in low intensity conflicts, e.g., counter-terrorist activity or certain peace-keeping missions. The problem is further exacerbated because little is known about ambient traffic. It is likely that this "clutter" will not be properly modeled as an ergotic stochastic process, as is the case with most signal-processing noise. However, even for the case of low intensity conflicts, purposeful movement patterns will occur due to physical constraints imposed by terrain, vehicle capabilities, and survivability. Anecdotal evidence suggests that purposeful motion patterns are manually discernible in the temporal-spatial record of MTI radar data with little or no a priori knowledge of movement patterns. This topic will pursue an inductive approach to MPA and seeks proposals that will develop techniques and tools to automatically identify and extract purposeful motion patterns from moving target data.

PHASE I: Using customer-supplied MTI data and user input (1) develop a mathematical formalism capturing current manual MPA techniques; (2) develop a description of candidate MPA features and extraction tools to detect and classify purposeful motion in ambient traffic; and, (3) develop a statistical description of ambient traffic clutter.

PHASE II: Develop a proof-of-concept MPA feature extractor and evaluate with customer-supplied, ground-truthed data.

PHASE III DUAL USE APPLICATIONS: This technology is applicable to a variety of commercial situations. The automated detection and identification of moving vehicle patterns will play a key role in the automated traffic flow monitoring and timely traffic re-routing in the "smart highways" of the future. In addition, inductive MPA techniques may be applied to the appropriate sensor data to automatically detect and classify migratory patterns of endangered species. Finally, sales patterns of individual or sector equities and commodities may be analogous to motion patterns; timely detection and classification of patterns would support timely decision-making in the business and financial markets. This technology directly supports the military's need for real-time Battlefield Awareness. MPA techniques will allow next generation airborne Intelligent, Surveillance and Reconnaissance (ISR) platforms, that are equipped with ground monitoring MTI sensors, to identify militarily purposeful movement on the battlefield. This information will supply the warfighter with real-time knowledge of enemy actions and intent. Specific application platforms include the Joint Surveillance and Attack Radar System (Joint STARS), the U-2, and the emerging Tier II+ Global Hawk.

DARPA SB972-075 TITLE: Open Architecture Security Tools

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a set of standard application programming interfaces (APIs) for use in security tools and for integrating security functionality into systems. Modify a set of existing tools to conform to those interfaces. These interfaces will define standard messages, protocols, functionality, and semantics for modules that perform intrusion detection, diagnosis, automatic response, traffic filtering, access control, and so on. These interfaces will allow such security modules to be integrated into products and systems such as firewalls, network management tools, intrusion detection systems, routers, and operating systems.

DESCRIPTION: Research and development is sought leading to security systems and tools, such as firewalls and intrusion detection systems, that will allow for much greater ability to evolve to accept stronger security solutions than is possible with today's technology.

The use of standard interfaces allows the plug-and-play use of different forms of the same function; for example, modules implementing different types of intrusion detection analysis. Such interfaces will allow computing and network technology to include security functionality in a way that facilitates growth and evolution. For example, a firewall could use these standard interfaces to include one or more intrusion detection analysis modules, and these modules could later be replaced with better technology using the same interfaces. The interface should allow a module to be implemented in software or hardware. Standard interfaces facilitate reuse; for example, the same intrusion detection analysis modules could be used in network management tools and in intrusion detection systems. Standard interfaces also promote the emergence of niche vendors who supply the security modules, independent from the vendors who supply the systems that use the modules. In developing the interfaces, special attention must be paid to ensure that all currently known and envisioned forms of a security service or functionality can be made to use the interface.

Examples of modules that conform to these interfaces, and modified versions of existing systems that include these modules, will serve as reference implementations. These reference implementations will serve as guides for vendors and developers to use in understanding how to use the interfaces in their products and systems. We envision that these interfaces will be used analogously to the way cryptographic application programming interfaces (CAPIs) are currently being used for open implementations of systems that use cryptographic security services. These interfaces may be logically combined with CAPIs to form a more complete set of security service APIs. For example, the API called for under DARPA SB972-074, "Security Self-Checking Tools for the Global Command and Control System Leading Edge Services (GCCS-LES) Architecture" should fit into the general framework described here.

PHASE I: In detail, identify the interfaces to be defined, and the type of functionality and semantics that must be captured in the APIs. Define the process by which the APIs will be developed. Describe a plan for developing security modules that are conformant to the APIs and for modifying one or more existing security tools or systems (for example, firewalls or intrusion detection systems) so that they use the APIs and can accept the modules.

PHASE II: Develop prototypes of one or more security tools or systems that are conformant to the APIs developed in Phase I and that contain a collection of API-conformant security modules to implement their security functionality. In addition to the prototypes, produce documentation, as well as an experimental evaluation of the open architectural approach. Complete documentation of test cases and results must be delivered. The developer should work with the relevant bodies, players, and major users in the security industry to gain community acceptance of the APIs, modifying them where necessary to accommodate various requirements that arise in the process. In addition to conforming to the APIs, security modules should also be characterized according to their effectiveness, strength, and costs, including processing overhead, storage and bandwidth requirements, and management costs.

PHASE III DUAL USE APPLICATIONS: The development of standard interfaces to security functions and services will accelerate the introduction of such functions and services into products and systems. This will make it possible for vendors to design and build products that conform to the security interfaces without having to understand the security, or to implement the services themselves. Standard interfaces will lead to the emergence of vendors who supply a diverse set of security functions and services, conformant to the interfaces, with different strengths, effectiveness, and costs. Thus, such standard interfaces can help to establish new markets for security functionality. This will also make it more cost-effective to develop products and systems that use security, and will make it easier to upgrade to better security solutions as they become available. Effective software security systems are mandatory for military computing and networking programs.

DARPA SB972-076 TITLE: Real-Time Network Performance Diagnosis

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop methods for diagnosing network performance problems in real-time.

DESCRIPTION: Vendors today provide tools that show the network configuration and gross traffic measurements, but this is insufficient to discover anomalies with respect to reasonable behavior. The development of an object-oriented tool that can integrate three critical functions would make it possible to detect and correct problems within minutes. The functions are modeling, monitoring, and correlating. If this is done in an object-oriented fashion, and if it makes use of standard protocols such as simple network management protocol (SNMP), then the possibility of commercialization is great.

PHASE I: The first phase of the project is to develop a prototype system that includes interactive graphics for describing the components of a local area network (LAN) and its interconnections to other LANs or internetworks. The description must include hooks for modeling the expected behavior (bandwidth, latency, queuing, etc.), and for monitoring the runtime behavior, via traffic probes, SNMP, remote monitoring, load measurements, etc. The modeled and observed behaviors must be displayed in a lucid manner that assists analysts and operators, and can be easily modified. The LAN descriptions must be modifiable and composable in a simple fashion.

PHASE II: Make the tool available on commercially available platforms and add diagnosis capability. Take measurements of runtime traffic, both the offered traffic at end systems and the observed traffic at routers, firewalls, gateways, etc., and compare them to what the models predict, for example, if the system should be able to identify machines that have an abnormal number of ethernet collisions with respect to other machines on the network. Routers that drop too many packets in comparison with the offered traffic should be identifiable automatically.

PHASE III DUAL USE APPLICATIONS: This would be a valuable tool for any organization that has a growing set of LANs with internal connectivity. Internet service providers could use the tool for diagnosing their service level and inter-provider service agreements. Network management firms could deploy it at their customer's sites, and provide superior maintenance capability at lower cost. This tool will be used in a military tactical environment to diagnose networking problem.

DARPA SB972-077 TITLE: Accelerating Network Protocols

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: To maximize the throughput of internet protocols by utilizing detailed knowledge of the protocol semantics.

DESCRIPTION: Internet protocols are written in a layered fashion that provide simple interfaces and limited visibility into the internal state of each layer. However, it is possible for intermediate processing elements in the network to take advantage of knowledge of the protocols and observed real-time behavior to improve observed performance. For example, a protocol that provides end-to-end reliability might be improved if the network kept some memory of delivered data and could respond to retransmission requests without communicating with the actual sender.

PHASE I: A report on which Internet protocols could benefit from acceleration techniques, and descriptions of techniques. Simulation results demonstrating expected improvements in at least three protocols.

PHASE II: The Phase II will include mathematical models and runtime results extending the analysis in Phase I, and protocols ready for deployment in network elements (e.g., firewalls, gateways, routers, switches) with documentation about expected performance gains.

PHASE III DUAL USE APPLICATIONS: There is potential for commercial products for workstations, web servers, and router software that provide greater use of existing network facilities by protocol accelerators. Multicast sessions, in particular, can be tuned to current network performance to take advantage of buffering, caching, fast retransmits, and fast acknowledgements. Military operations would benefit from increased performance on military equipment.

DARPA SB972-078 TITLE: Multilevel Performance Frameworks and Tools for High Performance Systems

KEY TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Creation or robust implementation of performance methods and tools for modeling, measurement, analysis and evaluation of parallel and networked systems, and the applications executing on such systems. Special emphasis will be placed on frameworks and tools that support large scale parallel systems and those that can support (heterogeneous) distributed systems and enable understanding and predicting the behavior of such systems.

DESCRIPTION: Research and development leading to prototype frameworks and tools supporting the development needs of high performance computing and communications systems, hardware as well as software is sought. Substantial improvements in the current tools and methods are needed to measure, model, and analyze computer systems, at all levels (from the application, to the software, to the hardware level), and to develop a performance framework to permit analysis of the entire system. Efforts may encompass the development of novel performance frameworks and tools, or the creation of robust implementations of existing prototypes, geared to address the needs for measurement and analysis of systems computational requirements, as well as communication and I/O requirements. Such frameworks and tools should include, but are not limited to: multilevel measurement and abstraction capabilities, multilevel model validation and integration, functional specification methods, performance specification languages, and performance analysis visualization tools. Ability to use the tools for collecting measurements on existing hardware and software platforms and extrapolating to analysis and prediction of performance of future hardware and software designs is considered important.

PHASE I: In detail, define the methods and the tools to be developed, the performance framework architecture, the technical approaches, interfaces, tradeoffs, and enhancements over current approaches or existing tools, together with feasibility analysis, identifying the testbed systems, and providing measurable criteria of the validity and success of the approach.

PHASE II: Prototype, develop, demonstrate, evaluate and deliver performance frameworks and integrated support environments for analysis and prediction of the performance of hardware and software systems, including numerically intensive applications, along with evidence that demonstrates the enhancements made by this work, and providing the associated documentation for using such tools.

PHASE III DUAL USE APPLICATIONS: Lack of adequate multilevel performance analysis and prediction capabilities has hampered building effective high performance parallel and distributed systems whose behavior and design tradeoffs are well understood. The present effort can contribute towards creating tools that allow the possiblitiy to skip generations of prototypes of such systems, and understanding their behavior as at the range of large numbers of processors and large applications, which will aid and expedite the development of applications, software, and parallel and distributed high performance machines critical to DoD's needs.

DARPA SB972-079 TITLE: Mobile Oceanographic Sensor Suite

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a suite of low-cost mobile oceanographic sensors that can be used by tactical platforms for on-site environmental characterization of the littoral. Such sensors would provide global knowledge of acoustic propagation, radically enhancing acoustic surveillance and weapon homing.

DESCRIPTION: Presently, tactical platforms possess limited environmental sensors onboard, or are easily available for deployment in-situ. Since the littoral is highly variable, both temporally and spatially, a need for local rapid environmental measurements is apparent. The resultant data set will enable the platforms to make more efficient use of sensor suites to perform assigned missions. The sensor suite will supply the needed cornerstone for underwater scene understanding.

PHASE I: Develop a set of requirements that will identify existing sensors and highlight those areas where advanced concepts are required. Also include the development of a concept of operations to make efficient use of the sensors over large areas of the littoral and the integration into a collaborative approach among all platforms with respect to mission accomplishment.

PHASE II: Design a prototype mobile system containing a suite of environmental measurement devices that can assist tactical platforms in optimizing the use of their sensors in littoral regions of interest. The design should address the means to communicate the collected data to the tactical platforms so that a collaborative effort to mission execution can be effected.

PHASE III DUAL USE APPLICATIONS: The resultant mobile measuring devices will be of use in the oceanographic fisheries and petroleum industries to determine the character of the water column, and the geological features that support underwater commerce, and will provide the oceanographic community an advanced suite of sensors on a convenient platform to rapidly collect oceanographic data (e.g., physical, chemical, geoacoustic). Such data would enhance macroscopic weather modeling and prediction by providing coherence studies of surface and subsurface phenomenology. From a military standpoint, this effort will characterize the in-situ water column to allow for the calculation of sensor performance predictions in the local environment.

DARPA SB972-080 TITLE: Multi-Modal Interface for Command and Control of Military Robots

KEY TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Creation and evaluation of multi-modal human/robot interfaces enabling command and control of remote robotic vehicles.

DESCRIPTION: Research and development leading to interfaces that enable users to receive information from and send commands to remote robotic vehicles while the users are in field or combat environments. DARPA seeks an interface more compact and employing more sensor modalities than the interface developed on the Unmanned Groud Vehicle. Modalities of interest include speech, simplified keyboard, laser pointer, and others.

PHASE I: Develop and demonstrate a multi-modal human/robot interface capable of recognizing inputs from a single user for command and control of robotic vehicles.

PHASE II: Develop, demonstrate, and deliver a multi-modal human/robot interface capable of recognizing inputs from multiple users in field and combat settings. Conduct tests to quantify performance of interface. Complete documentation of test procedures, cases, and results must be delivered.

PHASE III DUAL USE APPLICATIONS: The development of multi-modal interfaces for robot control will expand markets for robots, particularly field robots, and mobility aids for the disabled. The ability to receive and send commands to remote robotic vehicles is mandatory in combat environments.

DARPA SB972-081 TITLE: Tactical Grade Inertial Navigation System (INS) using Microelectromechanical Sensor (MEMS) Technology

KEY TECHNOLOGY AREA: Sensors; Electronics

OBJECTIVE: Exploit the MEMS technology base to develop a tactical grade INS featuring low power, small size, and light weight.

DESCRIPTION: Conduct research and development leading to the demonstration of an INS. Current MEMS technology includes miniature accelerometers and gyros, but not the integration of the two into a useful INS. The goals for this effort are: 1) Demonstrate solid state based (i.e., silicon) MEMS fabricated gyros (angle rate sensor) and accelerometers (linear velocity rate sensor) improved to tactical grade (1.0 to 10.0 degree/hour angle rate bias and 500 µg bias on acceleration); 2) Integrate these sensors into a low power (less than 1 Watt) and very small (less than 10 cubic inches with variable form factor per application) INS; and, 3) Demonstrate a complete breadboard system using Personal Computer Memory Card International Association (PCMCIA) data/bus interface standard.

PHASE I: Identify MEMS sensors and system design, and provide first level INS design mechanical layout. Identify navigation software approach.

PHASE II: Integrate sensors to inertial block and implement INS software on a system processor. Perform breadboard laboratory demonstration of a complete system with option for field demonstration.

PHASE III DUAL USE APPLICATIONS: A broad range of applications exists in the area of commercial navigation/dead reckoning systems to augment GPS receivers. These systems are currently limited by GPS outage, particularly in urban environments. Other areas exist in embedded inertial rate sensors for automotive applications (e.g., anti-spin out sensor, active suspension), train control, and commercial drilling applications. From a military standpoint, small size and low power enable man portability and use when GPS signals are obscured, e.g., for operations in buildings, under multiple tree canopy, etc. These attributes, along with low cost, also are appropriate for guided munitions and small unmanned air vehicles.

DARPA SB972-082 TITLE: Robotic Mechanisms Capable of Attaching Themselves to Moving Ground Vehicles

KEY TECHNOLOGY AREA: Ground Vehicles

OBJECTIVE: Design, development, and validation of robotic mechanisms capable of attaching themselves to moving ground vehicles.

DESCRIPTION: Research and development of robotic mechanisms capable of detecting and localizing moving ground vehicles, and attaching themselves to those vehicles as they travel near the mechanism. Evaluation of mechanism design must quantify mass, volume, power, and expected cost of manufacture. Evaluation of mechanism performance must include (but need not be limited to) tests with independent variables of vehicle type and vehicle speed, and with dependent variable of success of attachment.

PHASE I: Define, design, and simulate robotic mechanisms exhibiting the self-mobility required to attach themselves to moving ground vehicles.

PHASE II: Fabricate and evaluate self-mobile robotic mechanisms capable of attaching themselves to moving ground vehicles. Documentation of tests must be delivered, including information on the test methods and test results.

PHASE III DUAL USE APPLICATIONS: The development of miniaturized, low-cost robotic mechanisms, capable of attaching themselves to moving vehicles, will expand markets for material handling robots that perform loading and unloading operations, medical robots that handle surgical tools, and manufacturing robots that manipulate parts. This technology will be used by military troops to track and target enemy vehicles.

DARPA SB972-083 TITLE: Man Portable Smoke Generator

KEY TECHNOLOGY AREA: Manpower, Personnel and Training; Sensors

OBJECTIVE: Provide a man portable smoke generator capable of rapidly dispensing a non-toxic, environmentally friendly screening smoke transparent to long wavelength infrared (LWIR) viewing devices, but opaque to visible through short wavelength infrared (SWIR), in support of small unit combat and confrontational non-combat operations.

DESCRIPTION: A man portable smoke generating system capable of rapidly generating a screening smoke employing fog oil or other appropriate petroleum or vegetable agents is envisioned. A back pack tank holding 3-5 gallons of agent is desired. The selected screening agent should produce a rapid screen transparent to LWIR viewing devices. It is desired that the screening agent be projected forward from the operator under the operator's control. The system should be capable of dispensing a 400 square meter cloud in under 45 seconds; the cloud should persist for at least 20 minutes in ideal (no wind) conditions.

PHASE I: Contractors will provide two prototype systems capable of dispensing standard Army fog oil for test and demonstration of suitability and capability. Other potential agents should be identified, but should be non-toxic and environmentally friendly.

PHASE II: Contractors will modify their prototype systems to correct functional and other deficiencies identified during Phase I. A total of six systems configured for field test and in a near production ready configuration will be provided. During this phase, additional agents other than fog oil will be tested. These additional agents will include those recommended by the contractor and others that may be selected by DARPA in consultation with the Project Manager, Smoke/Obscurants, at Aberdeen Proving Ground, MD.

PHASE III DUAL USE APPLICATIONS: Law enforcement agencies frequently encounter confrontational and potentially violent situations where denying vision to engaged persons not equipped with thermal viewers would provide a powerful tool for a non-violent resolution. Riot control, hostage rescue, and apprehension of entrenched violators are examples. Military troops need portable smoke generators to provide cover on the battlefield.

DARPA SB972-084 TITLE: Two-Dimensional In-Plane Thermal Deformation Measurement for Large Area Substrates

KEY TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop processes and equipment that allow high-speed, automated scanning and analysis of large area electronic substrates to determine in-plane deformation under temperature cycling.

DESCRIPTION: Large area manufacturing processes for high performance/low-cost electronics systems are being developed for batch fabrication of multichip module (MCM) and high density laminate substrates. This approach raises reliability questions concerning differential thermal expansion between substrates and components during fabrication, test, and operation. The deleterious affects of sheer stresses, creep, solder joint fracture, and delamination need to be countered through the gathering of comprehensive empirical data, which will aid in materials selection, improving component layout, and will provide information towards completing reliability models under development. As substrates continue to get thinner to save weight and reduce size, circuit density will increase, leading to greater thermo-mechanical interactions between the components and the substrate. A machine of moderate cost enabling rapid acquisition and analysis of warpage data for large area bare and populated electronic substrates is needed to address reliability concerns for military, automotive, and industrial electronics.

PHASE I: Examine sensors and data acquisition methods (including visible, infrared (IR), and shadow moire) to determine most effective techniques for broad warpage measurements. Develop breadboard candidate approaches to aid in developing an engineering prototype for fabrication in Phase II. Develop sample preparation procedures and provide experimental evidence of analysis sensitivity, reproducibility, and speed.

PHASE II: Construct prototype based on design from Phase I. Capabilities must include large area substrates at least 12δ x 12δ, reflow soldering simulation temperatures up to 300□C, and thermal cycling temperatures ranging from -55□C to +125□C. Enhancements such as thermal shock simulation and high speed data analysis shall be investigated.

PHASE III DUAL USE APPLICATIONS: Applications are abundant in the automotive, industrial and telecommunications markets. Electronics reliability requirements for these markets are often just as stringent as military requirements. Thermally efficient designs, enhanced manufacturing yields, and increased reliability are available through the development of this inspection/analysis tool. Commercial designs, especially in the Personal Computer Memory Card International Association (PCMCIA) circuit card market, are seeking to pack chips in a much higher density on an extremely thin substrate, leading to reliability problems from stress buildup between the chips and substrate. Smaller and smaller telecommunications devices are built upon thinner and thinner substrates, leading to warpage problems. These products are typically fabricated and assembled while in a large panel form, and the stresses to individual coupons on a large panel during the manufacturing process can be better understood through the use of the proposed tool. The capability to determine high stress areas through warpage mapping is highly desirable in the commercial arena, as well as the military community. This program has applications in all military electronic systems, including missile guidance and control, and all of the support equipment utilized to service this equipment. It would be utilized in both the manufacturing of circuit boards and large multi-layer components, and in servicing of the manufactured items. The same use is present for commercial electronics utilized in TV and satellite systems as well as the computer industry.

REFERENCES:
1) Michael R. Stiteler, Charles Ume, and Brian Leutz, "In-Process Board Warpage Measurement in a Lab Scale Wave Solder Oven," 46th Electronics Components and Technology Conference Proceedings, Orlando, FL, May 1996.
2) F.P. Chiang, "Moire Methods of Strain Analysis," Chap. 6, Manual of Experimental Stress Analysts, 3rd ed., A.S. Kobayashi, Ed., Society of Experimental Stress Analysis, Bookfield Center, CT 1978.
3) I.G. Zewi, I.M. Daniel, and J.T. Gotro, "Residual Stresses and Warpage in Woven-Glass/Epoxy Laminates," Society of Experimental Mechanics Fall Conference Proceedings, Grenelefe, FL, November 1985.
4) Various publications available from the Optomechanics Research Lab at Binghamton University Internet site: http://omrl.me.binghamton.edu/

DARPA SB972-085 TITLE: <u>In-Situ Optical Fiber Stress Profilometer</u>

KEY TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: There is a requirement for new and innovative approaches to measure the stress profile along a length of optical fiber. The objective is to determine the best approach or approaches, demonstrate their practicality, and build a prototype stress profilometer.

DESCRIPTION: The use of optical fiber data links in missile systems requires that the fiber deployment be a smooth rapid process during missile flight. If there is a flaw in the winding of the fiber on the deployment bobbin the fiber is vulnerable to breakage. One of the critical winding parameters is the stress profile. In order to validate winding models it is necessary to determine the stress profile on a wound optical fiber bobbin, preferably with a system that requires only access to one end of the fiber. Optical time delay reflectometers (OTDR) can operate this way, but their output is completely insensitive to the stress profile. Several techniques such as Brillouin scattering, coherent interferometry, and polarization interferometry have been proposed and investigated in the past. The overall technical requirements are a 1% measurement capability over at least ten kilometer fiber lengths for a typical stress of 108 N/m2.

PHASE I: Review stress mechanisms in optical fibers and determine the optical effects expected to provide the data signals. Study fabrication methods and fiber architectures for making special test fibers with distance markers and/or other internal fiber structures to provide a signal output in the event that intrinsic stress effects are found to be inadequate for use. Perform laboratory tests to verify operation of the candidate techniques, and perform a preliminary design of a prototype stress profilometer.

PHASE II: Perform advanced laboratory mtests and demonstrations of selected techniques. Perform the detailed design of the stress profilometer, procure components, assemble, integrate, test, calibrate and deliver the hardware system and all documentation.

COMMERCIAL POTENTIAL: This work would have significant impact in the commercial optical fiber communications fields, as it would allow remote stress profile measurements to pinpoint locations where optical fibers may be subject to breakage, thus allowing corrective action prior to breakage so that the comunications systems are not disrupted.

REFERENCES:
1. "Tensile Strain Dependence of Brillouin frequency Shift in Silica Optical Fibers," T. Horiguchi, T. Kurashima, anf M Tateda, Proc. IEEE #1041-1135/89/0500-0107 (1989).
2. "A Differential Polarization Interferometer for Measurement of Residual Stress in Optical Fiber Bobbins," J. L. Johnson, Proc. of Workshop on Fiber Optics for Missile Applications, May 7-8 1996, Redstone Arsenal, AL.

DARPA SB972-086 TITLE: Wideband Optical Receivers

KEY TECHNOLOGY AREA: Command, Control and Communications (C3); Electronic Warfare

OBJECTIVE: Develop high-power handling, highly linear wideband optical detectors capable of efficient conversion of modulated optical signals to analog radio frequency (RF).

DESCRIPTION: Research and development leading to wideband detector receivers capable of highly linear/high efficiency conversion of modulated optical carrier-based signals from optical waveguides to RF carrier-based signals. Detectors must be capable of handling high optical power levels (>20 milliwatts) and remain linear. Detector receivers must be capable of wideband operation from 20-100 GHz without distortion. Optical wavelengths of interest are 1.3 and 1.55 microns.

PHASE I: Develop tradeoff design approaches and wideband detector receivers with limited breadboarding.

PHASE II: Implement most promising detector design and incorporate into a link for evaluation.

PHASE III DUAL USE APPLICATIONS: This development has commercial applications in satellite receivers, television distribution systems, cellular radio, microwave radio relay, collision avoidance systems, and remote sensing. Military applications include large phased antennas, electronic warfare receivers, or signal intelligence platforms.

DARPA SB972-087 TITLE: Continuous Apertures

KEY TECHNOLOGY AREA: Electronic Warfare; Sensors; Command, Control and Communications (C3)

OBJECTIVE: Develop novel designs, techniques, and structures to synthesize apertures capable of efficient operation over broad frequency ranges and functions.

DESCRIPTION: Current antenna aperture designs are usually narrowband or, at best, optimized for a narrow set of frequencies, whether they be phased arrays or single radiators. Single point designs are, therefore, narrowly focussed, application specific and, thus, expensive. If an arbitrary aperture could be synthesized from a continuum (or near continuum) of radiators, the overall system cost could be greatly reduced. It is the purpose of this effort to research novel electromagnetic materials, optoelectronics, photonics, superconductivity, photonic bandgap structures, and antenna synthesis techniques to develop antenna building blocks such that arbitrary antenna structures and frequencies of operation can be synthesized. Measures of success are that the resulting synthesized apertures function nearly equal, or equal to, single point designs.

PHASE I: Define a design in detail, demonstrate potential by analysis/simulation and limited breadboarding.

PHASE II: Synthesize several apertures from a “continuum” of aperture functions and demonstrate performance compared to conventional antenna systems.

PHASE III DUAL USE APPLICATIONS: The development of continuous aperture technology will enable cost-effective implementation of wide frequency range apertures for commercial systems, e.g., cellular radio, direct broadcast TV, and mobile satcom. Antennas will become a fraction of their current cost because of the elimination of the need for specialized designs. Military applications include phased array antenna systems for ground, air, or space platforms; electronic warfare; signal intelligence; and satellite communications.

DARPA SB972-088 Title: Technologies for the Detection and Characterization of Deeply Buried Targets

KEY TECHNOLOGY AREA: Chemical and Biological Defense

OBJECTIVE: Concept development and prototype design specifications for technologies which enable detection and characterization of deeply buried targets.

DESCRIPTION: Nuclear, biological, and chemical (NBC) materials production, storage, and operations facilities may be located in underground facilities (UGF). The construction of these targets ranges from near surface targets ("cut and cover") to deeply buried targets (DBT) to hardened deeply buried targets (HDBT) whose only access points are reached via tunnels. In addition to the actual destruction or disablement of these threats, their negation requires the execution of three missions: broad area detection and identification, functional characterization (to include determination of UGF purpose, materials contents, operational status, etc.), and physical characterization (3-D geographic location, size, construction features, protective measures, security features, support equipment such as HVAC and prime power, etc.). The targets' location in denied areas imposes additional requirements of covertness and/or long standoff range for these missions.

DARPA is soliciting proposals for sensor technologies which support the broad area detection and characterization functions. Candidate technologies should support reasonable operational employment concepts, such as, use by special operations forces, unattended ground sensors, low observable unmanned air/ground vehicles, or stand-off airborne platforms.

PHASE I: Provide a sensor technology feasibility assessment and concept design. Include preliminary performance predictions/results and a development roadmap for the recommended technologies. Indicate how devices fit into operational employment concepts. Provide estimates of unit cost and producibility, along with requirements for packaging, prime power, processing, and communications.

PHASE II: Provide detailed device designs. Develop breadboard component hardware which can lead to a fieldable system design. Perform field test demonstration of devices.

PHASE III DUAL USE APPLICATIONS: Successful conclusion of this development effort may lead to important sensing capabilities for civil defense, disaster response, geological survey, mining, and environmental air/water quality monitoring. From a military standpoint, insertion of this technology on a number of platforms supports a broad spectrum of counter-proliferation concerns.

DARPA SB972-089 TITLE: Instrumentation for Nanostructure Analysis

KEY TECHNOLOGY AREA: Command, Control and Communications (C3)

OBJECTIVE: Develop the capability to analyze nanostructures with diagnostics or characterization tools to enable advanced microelectronics and nanoelectronics in the sub-50 nm regime.

DESCRIPTION: As critical electronic device dimensions go substantially into the sub-100 nm regime, characterization and diagnostic tools will have increasing difficulty in detecting defects and impurities, and performing the detailed material analysis, and analysis of the electronic behavior which is required in this size regime. This topic seeks to address this area through further research, development, and integration of microanalysis instrumentation into advanced electronics which have resulted from DoD and other basic research investments.

One area is the ability to measure elements having a high ionization potential including hydrogen, carbon, nitrogen, oxygen, and fluorine. However, these elements are very difficult to measure quantitatively at the needed resolution. Capabilities are needed which allow sub-50 nm resolution, and quantitative measurements of these elements with very high efficiency, sensitivity, and selectivity. Very important, also, at this reduced scale is that one needs to examine the electronic behavior, both spatially and temporally, using such tools as nanoprobes. Another area, for example, is to explore the limits of tools such as the microcalorimeter for x-ray microanalysis. X-ray spectroscopy is one of the most sensitive non-destructive elemental analysis techniques. It can furnish the elemental composition of an array of structures. Chemical identification and classification of particles in the submicron regime is one of the major problems facing processing of advanced electronic devices.

As we progress to small electronic device structures and extremely high density circuitry, the performance requirements for micro- and nano-analysis equipment are pushed beyond the current equipment limits. As next generation devices become available with critical feature sizes well below 100 and even 50-nm, the proper analytical tools need to be available.

PHASE I: Develop detailed designs and show feasibility of critical concepts for nanocharacterization.

PHASE II: Develop and demonstrate complete prototype instrumentation and demonstrate that it meets goals and specifications originally targeted. Successful proto-typing in Phase II would increase the probability of a Phase III.

PHASE III DUAL USE APPLICATIONS: More cost-effective growth and processing of advanced material and device structures; reliable electronic and optoelectronic device structures; improved high frequency and low power electronics; quantum well detectors and emitters; process and device structure verification. Currently, military and civilian electronic systems can be made of devices which have elements and structures so small that it is virtually impossible to test the extremely high device performance with standard instrumentation. The Phase III program seeks to overcome the limitations in characterization and diagnostics such that advanced ultra small devices may be exploited to their fullest potential. Making the appropriate tools available to the microelectronics industry would greatly benefit the development of future DoD advanced electronics, magnetics, optics, and micro-mechanical systems.

DARPA SB972-090 TITLE: Spatial-Spectral Automatic Target Recognition (ATR)

KEY TECHNOLOGY AREA: Exploratory Development

OBJECTIVE: Develop and test algorithms and systems to support airborne, real-time automatic target detection and identification using combined EO/IR spatial and spectral discriminants.

DESCRIPTION: Automatic target recognition has long been a required military capability; results of Desert Storm reinforce the need to automatically detect and identify military targets and to locate the targets with sufficient accuracy to perform precision strikes. The requirements to overcome the effects of camouflage, concealment, and deception (CC&D) and to detect targets in deep hide have added to the difficulty of detecting and identifying time critical targets. Spectral-based (multispectral and hyperspectral) imaging sensor systems, operating in conjunction with other sensors, offer the potential to automatically detect military targets with high probabilities of detection and associated low false alarm rates, over limited search areas, and to support man-in-the-loop or automatic weapon delivery. Much research has been performed in spatial ATR. This effort seeks to optimally combine results from this previous spatial-based ATR work with emerging spectral-based discrimination techniques.

PHASE I: Identify novel concepts and approaches for spatial-spectral ATR. Quantify ATR performance within the spatial-spectral trade space and compare results to classical ATR approaches. Develop a system concept for applying the ATR approaches to current or planned airborne spectral imaging sensor systems. Define Phase II approach.

PHASE II: Demonstrate the selected approaches and algorithms in a real-time, automated processing environment supporting a civilian or military remote sensing system.

PHASE III DUAL USE APPLICATIONS: Spatial-spectral ATR systems may be used by other government agencies and the civilian sector for environmental and remote spectral sensing applications.

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Schwartz, Craig R., et al., “Thermal multispectral detection of military vehicles in vegetated and desert backgrounds,” Proceedings of the SPIE, Vol. 2742-30, Orlando, FL, April 1996.