OSD Deputy Director of Defense Research and Engineering

Small Business Innovation Research Program

PROGRAM DESCRIPTION

The Army, Navy and Air Force acting on behalf of the Deputy Director of Defense Research & Engineering (DDDR&E) Office of Technology Transition, invite small business firms to submit proposals under these 21 OSD DDDR&E topics. Firms, with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, DDR&E will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector.

Objectives of the DDDR&E SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results. The DDR&E Program presented in this section strives to encourage technology transfer with a focus on advanced development projects with a high probability of commercialization success, both in the government and private sector.

DDDR&E may elect to fund several or none of the proposed approaches to the same topic. We anticipate awarding 2 to 3 Phase I contracts per topic. However, there is no commitment by the DDR&E to make any awards on any topic, to make a specific number of awards or to be responsible for any money expended by the proposer before award of a contract. Phase I will typically be $100,000, for one half-person year effort over a period not to exceed six months. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other applications. If it appears to have such potential, proposers are encouraged, on an optional basis, to obtain a contingent commitment for private follow-on funding to pursue further development of the commercial potential after the government funded research and development phases.

Phase II awards will be made subject to the availability of fund, on the basis, first, of results from the Phase I effort and second, on the scientific and technical merit of the Phase II proposal, and also based on the presence of matching funds from independent third-party investors, per the SBIR fast track (see Section 4.5). Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation) and may be up to $750,000. We anticipate that approximately one-third of Phase I awards will result in Phase II projects. For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that have successfully completed their Phase I contract efforts, will be considered.

An important goal of the program is conversion of DoD-supported research and development into commercial products. Proposers are encouraged to obtain a contingent commitment for private follow-on funding prior to Phase II where it is felt that the research and development has commercial potential in the private sector.

Questions pertaining to a specific topic should be directed to the point of contact listed in each topic. Phase I proposals written in response to OSD topics in this solicitation should be submitted to the designated office and address indicated on the next page.

OSD FY96 Program
Proposal Submission

	Mailing Address	Phone Number
Topics OSD96-001 through OSD96-007:	Joyce Crisci US Army CECOM ATTN: AMSEL-AC-BID Tinton Avenue CECOM Office Building Fort Monmouth, NJ 07703-5008	(908) 427-2665
Topics OSD96-008 through OSD96-014:	Office of Naval Research ATTN: Mr. Vincent D. Schaper ONR 362 SBIR 800 North Quincy Street Arlington, VA 22217-5660	(703) 696-8528
Topic OSD96-015:	Phillips Laboratory OLAC PL/RKS (Doug Talley) 10 E Saturn Blvd Edwards AFB, CA 93524-7660	(805) 275-6174
Topic OSD96-016:	Phillips Laboratory Propulsion Laboratory OL-AC PL/RKS Attn: Cpt Scott Wierschke 10 E Saturn Blvd Edwards AFB, CA 93524	(805) 275-5623
Topic OSD96-017:	Rome Lab Attn: Margot Ashcroft 26 Electronic Parkway Rome, NY 13441-4514	(315) 330-3021 Capt B Clarke, Tech POC
Topic OSD96-018:	Rome Lab Attn: Margot Ashcroft 26 Electronic Parkway Rome, NY 13441-4514	(315) 330-3021 A Jamberdino, Tech POC
Topic OSD96-019:	Wright Laboratory Aero Propulsion and Power Directorate 1950 Fifth St, Rm 105A WL/POMX, Bldg 18 Wright-Patterson AFB OH 45433-7251	(513) 255-3428 Betty Siferd
Topic OSD96-020:	Wright Laboratory Materials Directorate 2977 P St, Ste 13 WL/MLIP, Bldg 653 Wright-Patterson AFB OH 45433-7746	(513) 255-7175 Sharon Starr

Topic OSD96-021:

Technical Transition Office (916) 643-1248
SM-ALC/CN
Kim Chaves
3237 Peacekeeper Way
McClellan AFB, CA 95652-1056

OSD FY96 Topic Descriptions

ARMY, Communications-Electronics Command (CECOM)

OSD96-001 TITLE: Hydrogen Supply System for Small Proton Exchange Membrane (PEM) Fuel Cell Stacks

CATEGORY: Exploratory Development

OBJECTIVE: A compact, lightweight, rechargeable hydrogen supply system is sought.

DESCRIPTION: The system will deliver clean hydrogen at rates up to 10 grams per hour and will operate over all military environments. The hydrogen quality and delivery pressure shall be compatible with the hydrogen demands of small PEM fuel cell stacks of up to 200 watts. The hydrogen delivery system shall produce 10% hydrogen, by weight, based on the system weight. The total hydrogen required will range from 10 grams to 120 grams. Requirements for safety, transportation, and reliability shall also be addressed.

PHASE I: Phase I will consist of mass and energy balances with supporting experiments. Safety, transportation, storage, human factors engineering, cost, and reliability will be analyzed during this phase.

PHASE II: Phase II will consist of prototype fabrication and test and will integrate the hydrogen system with a fuel cell stack and controls to produce a complete fuel cell power source which will be demonstrated. A specification for the hydrogen subsystem will be developed. It is anticipated that existing fuel cell stacks will be obtained for this phase and fuel cell stack development will not be part of the phase II effort.

POTENTIAL COMMERCIAL MARKET: Small Fuel Cell Power Sources are being developed by many companies for a wide variety of applications that now use batteries. These applications range from laptop computers to electric vehicles. The source of hydrogen for these systems is a key technological barrier especially in the sub kilowatt power range. The successful development of a simple rechargeable hydrogen system that produces 10% by weight hydrogen would benefit military and commercial programs and could lead to the introduction of practical fuel cell power system in both markets. Specific military use would be to replace the BA 5590 battery in missions where high power demand causes extremely short battery life.

OSD96-002TITLE:Small Screen Display Graphics Control for Situation Awareness (SA)

CATEGORY: Advanced Development

OBJECTIVE: Battlefield Information displayed on small screens in vehicles and Command Centers generally focuses alternately on either large areas lacking resolution or small areas lacking the broad view of SA. Over-dwelling in either display mode or transitioning between modes could result in awareness suppression of vital information that is already available to the operator. The objective is to augment the current view to suggest the content of the alternate.

DESCRIPTION: The purpose of this contract effort will be to develop graphics representations of data outside the current normal view in such a manner as to accurately convey zones of vulnerability to enemy attack and zones of influence over enemy positions without over burdening the visual capacities of the operator. The software module must be able to display standard features and military symbols on map overlays for the current view together with indicators of the presence and attributes of friendly and enemy forces reflecting the alternate views. Switching from current views and back should be virtually instantaneous. Audio and flashing visual warnings for survival threatening situations are also required.

PHASE I: Initial investigations will focus on the use of 1) descriptively-coded incremental peripheral range bands (range intervals) or vector lines to identify spheres of influence beyond the image displayed, 2) descriptively coded amorphous shapes to identify spheres of influence within a macro display, 3) background display (and off but ready displays) of alternate

views that could instantly replace the foreground view/overlay, and 4) audio/video alerts tied to predefined conditions or state changes, to significantly enhance the operator's battlefield environment awareness.

PHASE II: Develop a Common Module for CHS Application.

POTENTIAL COMMERCIAL MARKET: The results of this research can be adapted to any small or large screen application in which there is critical value to maintaining a simultaneous awareness of interrelated or interactive perspectives or processes. Installations having limited space or hardware availability, or needing emergency backup redundancy could benefit from this research. (Monitor fish schools on SONAR and other vessels on surface RADAR; navigate a narrow channel and be aware of vessels entering from the opposite direction; from an aircraft, observe localized wind shear or high wind conditions while tracking a weather front; follow an automobile route mapping small screen display and be aware of dynamic traffic patterns and hazards as well as alternate routes.)

OSD96-003TITLE:Predictive Filtering of Situation Awareness Position Information

CATEGORY: Engineering Development

OBJECTIVE: From a communication perspective, Position Awareness (target location) places the greatest demands on system bandwidth. Various approaches for minimizing the bandwidth demands of position awareness have been investigated and compared. An approach to distributing and maintaining position information using predictive filters is found to be very robust and to require very little bandwidth. This proposal is for the development of the Kalman filter algorithm for Situation Awareness Position information.

DESCRIPTION: Predictive filters are widely used to compress speech. The idea is to identify a predictable component in the speech signal which can be described by a few parameters. If the filter performs well, the bits necessary to encode the parameter values and deviations of the true signal from the predictive model will be less than that needed to encode the raw signal. The concept is simple and efficient. However, to be of any use, the process has to be optimized and the process has to be able to provide an error estimate. The Kalman filter is an optimal predictive filter for a wide class of linear processes with gaussian error statistics and is commonly used in a wide range of target tracking applications. The Kalman filter approach maintains the target state as a set of position, velocity and error values as a function of time. At a given point in time, a new position estimate is taken and an update is prepared. Bandwidth will be conserved by not sending updates if a predicted position is within position error requirements; and if maximum bandwidth allocations are exceeded. The optimum nature of the Kalman filter algorithm will guarantee minimum position error under bandwidth constraints.

PHASE I: Phase I will consist of seven parts. The contractor will (a) work with government technical staff to evaluate the bandwidth requirement for Position Awareness; (b) analyze the Kalman filter for implementation; (c) design the algorithm for optimal target tracking; (d) prepare test plan for testing; (e) document the algorithm; (f) prepare the software source code (test version) and design documents for delivery, and (g) conduct internal testing prior to final verification and evaluation, i.e., Phase II.

PHASE II: Phase II will consist of six parts. The contractor will (a) incorporate the predictive algorithm into a simulation model provided by the Government; (b) conduct computer simulations; (c) evaluate technical data; (d) depending on the test results, modify the predictive algorithm when necessary; and (e) prepare final software design documents and (f) source code for delivery.

POTENTIAL COMMERCIAL MARKET: The predictive algorithm will not be designed for particular target "signatures". The design approach will not require the target to enter plans but extracts a "plan" from the data and minimizes position information exchanges so long as the "plan" holds. When the target maneuvers, it deviates from the extracted "plan" and the position delta update rate increases momentarily and then decreases once a new stable trajectory is established. The algorithm will be designed to conserved bandwidth by not sending updates. It is envisioned that such technology will be beneficial to industries, such as: trucking, taxi, shipping, and airlines that require instantaneous knowledge of the locations of their assets. Knowing where their

assets are located at any given time will allow those industries to manage them more efficiently and deploy them expeditiously to meet new business opportunities.

OSD96-004TITLE:Extended-Mission Command and Control Platforms Utilizing Low Power Concepts In Portable Computing Environments

CATEGORY: Exploratory Development

OBJECTIVE: Currently, the Soldier System products (computers, GPS receivers, radios) being developed are limited in their operating time and mission use to twelve hours or less. This is a direct result of: 1) limited power densities for current battery technologies and 2) minimum power consumption limits for electronic components that cannot be reduced using current technologies. Highly promising work is underway in industry to achieve significant breakthroughs in electronic power consumption. This project will focus on leveraging these commercial advances that are still in the early stages of development and advancing them to a mature state for transition to use in Soldier System products. Accelerating these industry R&D efforts is necessary to meet the ambitious goals of future Soldier System products. In the immediate future, increased mission times of twenty-four and thirty-six hours would enhance the effectiveness of this system. As a long-range goal, future mission operating times of seventy two hours or greater in the 2002 timeframe can only be achieved by investing now in low power electronic development.
This project will explore the power reduction problem from a total integrated perspective, considering all aspects of the soldier systems consuming power, including processing capabilities, communication needs (data throughput), video capture requirements, utilization of low power electronics (reducing operating voltages below 3.3V, reducing internal gate capacitance, and utilizing parallel circuits), and power management methods, with the goal of reducing power consumption by 50% to 90% over present systems.

DESCRIPTION: Propose a computer command and control subsystem (i. e., CPU with motherboard and memory, Global Positioning System (GPS) Y-code receiver, voice recognition, and/or video capture/compression devices) for prototyping and packaging as a low power device. The devices proposed should interface with industry standard PC-based systems. Develop a migration plan for insertion of these devices into existing or planned Soldier System products (Land Warrior, Lightweight Leader Computer). High-efficiency DC-DC converters should also be planned for use in this system.

PHASE I: Develop a design and fabrication plan for a computer command and control subsystem (i. e., CPU with motherboard and memory, GPS Y-code receiver, voice recognition, and/or video capture/compression devices) for prototyping during Phase II. Include in this plan modeling and simulation results validating the planned approach.

PHASE II: Fabricate a prototype computer command and control subsystem (i.e., CPU with motherboard and memory, GPS Y-code receiver, voice recognition, and/or video capture/compression devices) for incorporation in existing or planned Soldier System products (Land Warrior, Lightweight Leader Computer). The prototype should interface with existing industry standard PC-based products.

POTENTIAL COMMERCIAL MARKET: Low power computing and sensor devices (i.e., CPUs, GPS receivers) can be utilized in the commercial marketplace by both laptop computer users, as well as outdoor sporting enthusiasts (boaters, hikers, campers). Power management hardware/software can also be applied to the same devices. The marketplace for these devices numbers in the tens of thousands. There is high demand for longer operating times of twenty-four or thirty-six hours for commercial laptops. Business travelers would consider the longer operating times a boon and corporate users would enthusiastically embrace this technology.

OSD96-005TITLE:Digital Wireless Communications

CATEGORY: Advanced Development

OBJECTIVE: Accelerate development of dual-use communications products for law enforcement, commercial, and military applications. Needed capabilities include data rates suitable to support multi-user, mobile, and secure video teleconferencing, bandwidth flexibility, handset operation across frequency bands commensurate with military and commercial applications, and small size factor for handhold application including lightweight and low cost. Innovative antenna techniques to support mobile, directive applications, including mechanically-steered stable platforms for extended range and relay applications, shall also be considered.

DESCRIPTION: Communications products (e.g., modulation techniques, digital signal processing, antenna technology, etc.) that support mobility and emerging multimedia communications, including networking standards like TCP/IP and ATM, and compatibility and interoperability with existing communications standards such as Broadband and Narrowband Code Division Multiple Access, Land Mobile Radio, Advanced Mobile Phone Service, and Global System for Mobile Communications, etc.) shall be considered. Compatibility with Cellular, Personal Communications Service (PCS), and Instrumentation Scientific Medical (ISM) frequency allocations is also required to support worldwide digital wireless communications. Satellite (PCS) and wireless LAN technology should also be considered to accomplish world wide coverage.

PHASE I: Study and recommendations report outlining detailed design methodology for achieving program objectives. Critical factors are the ability to handle multiple waveforms, frequency bands, and users in a secure mode with minimal design impact. In order to minimize production unit cost, the product should have both a tactical and commercial application such as worldwide PCS, Cellular, and ISM for operations other than war.

PHASE II: Fabrication of prototypes to support technology development. Prototypes should be of complexity suitable to determine success of meeting the stated objectives.

POTENTIAL COMMERCIAL MARKET: Military applications include a communications system suitable for worldwide deployment providing communications that will support connectivity from the foxhole to the operations commander. Law enforcement and commercial wireless vendor use is for PCS, wireless LANs, and other comm services requiring a level of security, and flexibility of services.

OSD96-006TITLE:Lightweight Rechargeable Batteries

CATEGORY: Advanced Development

OBJECTIVE: Develop advanced rechargeable batteries which may provide decreased weight or volume, lower overall operational costs, higher rate capability, improved safety characteristics, or decreased disposal problems. There will be increased demands placed on portable power sources as the number of communications and computer devices increases in the future, particularly in connection with the future Digitized Battlefield. There may also be opportunities for hybrid systems which combine the advantages of lower-rate capability primary and rechargeable batteries with the high rate capabilities of electrochemical capacitors and high rate batteries.

DESCRIPTION: Lightweight rechargeable batteries are required in order to substantially reduce the cost of battery power during training, as well as to provide critical tactical power sources for SOF missions where recharging energy is available. Other current technologies are based on conventional lead-acid and nickel-cadmium technologies, as well as on the initial products based on lithium-ion and nickel-metal hydride technology. These latter systems are just now being introduced into military batteries. However, there is a high probability that improved versions of these technologies, as well as other advanced rechargeable batteries (Lithium-polymer, etc.), will be developed for military and commercial use when the appropriate incentives are provided. In addition to battery systems, improved materials, such as high energy density cathodes, low temperature organic and polymer electrolytes, etc., are keys to providing improved battery systems.
Examples of the types of technology developments which are desired:

•Lower weight rechargeable batteries which are capable of operating over the temperature range from -40 to +65 C.

•Lower volume rechargeable batteries with the same characteristics.

•Lightweight batteries which exhibit superior charging characteristics, such as at high rates or high temperatures.

•Rechargeable batteries which exhibit the potential for very low operational costs during training, with or without the wide temperature operational range described above.

•Potentially low cost systems which exhibit the capability to provide high power operation for short periods, even though the temperature operational range is limited.

•High energy density rechargeable batteries which are inherently safe, and which may be shipped on commercial airlines without restrictions.

•Improved materials which either allow improvements in existing systems or make new systems feasible.

PHASE I: Initial research should focus on covering the idea/materials involved with the new concept, and an initial experimental demonstration.

PHASE II: Fabrication of a sufficient number of products to provide for both cycling tests and initial demonstrations in typical applications.

POTENTIAL COMMERCIAL MARKET: Batteries such as those described above are required for a wide range of military applications, such as in communications, night-vision devices, remote sensing, vehicle starting, etc. They have the same desired characteristics in general as those desired for commercial applications for lightweight power sources, such as for cellular telephones, portable computers, camcorders, etc. Products developed under this SBIR would clearly have uses both in military and commercial telecommunications and electronics applications.

OSD96-007TITLE:Advanced Lossless Data Compression Techniques for Portable Computing Environments

CATEGORY: Advanced Development

OBJECTIVE: To advance the state-of-the-art in high technology and moderate risk data compression techniques and transition these improved data compression techniques into existing Soldier System programs for use in portable computing environments, after reducing the technical risk. Improved data compression algorithms, coupled with improved file/message transfer protocols, will have widespread commercial use with laptop computers and remote computing (E-mail, Internet access via wireless or cellular links).

DESCRIPTION: In today's battlefield, the use of data to enhance the commander's intelligence and view of the battle is playing an ever increasing role. With the advent of the soldier as both a fighting system and live sensor under the Land Warrior concept, the data from digitized reports during an on-going battle and their subsequent transmission to rear echelon forces is becoming critical to command and control. A significant technical barrier to overcome is to reduce the amount of digital traffic over overloaded transmission links. Since it is projected that digital traffic will increase in the future, it is foreseeable that the channel capacity may not keep pace with the demand for transmitted information across the battlefield. Currently, little or no data compression is used on the battlefield when transmitting reports, textual data and database updates. This project will focus on leveraging commercial lossless data compression techniques and developing a new standard to be utilized by the Army in reducing the amount of data traffic transmitted, while still passing the same information. This project will benefit the Army tremendously by allowing the transmission of more digital information using existing tactical links in significantly less time than currently possible. Thus, a reduction in digital traffic on already overloaded communication links and networks will allow for the increased traffic demands of the 21st century battlefield.

The goal of this SBIR program is to incorporate this data compression technique coupled with improved message transfer protocols in portable computing environments, using the Soldier System platform as an initial demonstration point. This technology can readily transition to commercial laptop platforms for improved data storage, wireless connectivity and remote computing.

PHASE I: Perform a trade-off analysis of commercially available (including beta releases) lossless data compression techniques and file/message transfer protocols for portable PC platforms. This analysis should include a comparison of these techniques with current Army doctrine. Comparisons of compressed and uncompressed file sizes, along with compression and decompression times, should be included.

PHASE II: Select one or two of the most promising techniques from the Phase I trade-off analysis and incorporate this technique into a lightweight portable platform for further testing and demonstration purposes. The Government will provide the host computer platform from one of the products being developed for the Soldier System. If this platform is unavailable, a commercial laptop PC utilizing either Unix or Windows NT will be used. The exact details of the target operating system and host platform will be determined by the Government prior to the start of Phase II.

Upon the completion of Phase II, a working prototype of the data compression software incorporated into the Soldier System platform and integrated into the current Soldier System command and control applications program will be demonstrated and delivered. The command and control applications program will utilize Ada, however, the data compression and message/file transfer techniques may be coded in alternate languages if their code is pre-existing and leverages an existing commercial product. Stand-alone commercial versions of this improved data compression and file message transfer protocol software can be readily transitioned back into the commercial marketplace as an integrated software package.

POTENTIAL COMMERCIAL MARKET: The marketplace for this product is as large as the commercial PC field, since all personnel using a PC could benefit from highly compressed files for storage, transmission and eventual recall at a remote location. Improved file/message transfer protocols, coupled with the data compression, will ensure reliable receipt of data.

NAVY

OSD96-008TITLE:Cryocoolers for Cryoelectronics

OBJECTIVE: Develop a small, efficient, affordable, and reliable cryocooler for defense electronics systems. Innovative designs for conventional refrigeration cycles, approaches using non-conventional refrigeration cycles, and systems employing new materials are explicitly encouraged.

DESCRIPTION: Electronic systems operating at temperatures significantly below room temperature, cryoelectronics, offer a wide variety of opportunities for performance improvements in speed and sensitivity while operating at lower power levels and becoming smaller in size. Semiconducting materials operate at higher speeds with lower power consumption; superconducting materials offer zero (low) resistance material for interconnects, coils, filters, switching and logic elements, and electromagnetic detectors; and magnetic materials offer giant magnetoresistance phenomena and the possibility of spin-polarized devices. The foremost issue in developing this cryoelectronics technology is the development of small, efficient, affordable reliable refrigerators (cryocoolers) which can be integrated with the electronic systems. This topic focuses on the issues of reducing costs, increasing efficiencies, and increasing the reliability of cryocoolers.

PHASE I: Develop design of cryocooler and do preliminary calculations on efficiency and affordability. Indicate plan for incorporation in specific electronic systems. Goal is to have a Mean Time Before Maintenance of greater than 3 years and a cost of less than $1000 per unit.

PHASE II: Build cryocooler and demonstrate efficiency and reliability. Develop cost estimates and marketing plan for use of cryocoolers in specific electronic systems. Goals of program should be quantifiably met.

PHASE III: Incorporate cooler into an electronic system demonstration to quantify overall system performance benefits.

COMMERCIALIZATION POTENTIAL: Development of cryocoolers will find commercial applications in the cellular communications industry (high Q superconducting filters), in high network communications (low power, high speed switches), in air traffic guidance (high resolution radar), and in computer work stations and mainframes (low power logic, memory and interconnects elements).

REFERENCES:

1. Gubser, D. U. "Cryoelectronics: The Promise and the Challenge," Proceedings of the 1995 CEC/ICMC Conference (to be published)
2. For a review of Low Temperature Electronics, see Proceedings of First International Low Temperature Electronics Conference, Cryogenics 30, (December 1990) and IEEE Trans. Electron Devices (1987) ED34(1).
3. For a review of the field of superconducting electronics see IEEE Transactions on Applied Superconductivity (June 1995,) Vol. 5, Parts I and III.
4. For a review of High Speed ICs and Systems see Eden, R.C. "Applicability of Superconducting Interconnection Technology for High speed ICs and Systems" Final Reports on DARPA BAA 90-06 Contract N0014-90-C-0217, (October, 1991 and 1992).
5. For a review of the field of magneto-electronics see Prinz, G.A. Physics Today, (April 1995) p. 58.

OSD96-009TITLE:Displays for Avoiding Motion Sickness

OBJECTIVE: Develop and test head mounted displays (HMD) with gravity stabilization to counter motion sickness.

DESCRIPTION: Console operators in shipboard, land vehicle and airborne environments may suffer motion sickness when the vehicles are unstable while moving. The theory holds that conflict between visual orientation cues and orientation signals from the inner ear motion sensors (the vestibular apparatus) causes motion sickness. For example, in an interior room on a ship, the visual cues indicate that the room is stationary, but, as the ship pitches and rolls, the inner ear cues signal motion. If the operator viewed a gravity stabilized view in a head mounted display, visual and vestibular cues would be the same and motion sickness would be averted. As the ship moved, the orientation of the gravity vector would be directed to the display driver and the display would be altered appropriately. An alternative method of providing orientation cues may be to maintain the display screen orientation fixed in the HMD display screen, but provide a peripheral cue to orientation. Depending on the results of the first phase of testing this option may be pursued for closer examination. Companies are strongly encouraged to use existing HMDs rather than developing new ones so that the technology development can focus on testing and integration of orientation cues into the display.

PHASE I: Design proof of concept HMD and do controlled experiments in a simulator with a motion base. Test various movement sensors, filtering paradigms, display tilt modes, etc. to determine required and optimal values.

PHASE II: Conduct extensive testing in actual moving environments including ships, land vehicles, aircraft to further optimize of the movement sensors, filtering and cues. Determine characteristics appropriate to each environment tested. Test the option of allowing individual crew members to select system characteristics to accommodate variability in susceptibility to motion sickness. Demonstrate prototype technology including the HMD, head movement sensor, and demonstration software.

PHASE III: Production for sale to Navy and other government agencies.

COMMERCIAL POTENTIAL: The display would be applicable to any situation in which motion sickness has the potential of interfering with operator or passenger performance or comfort.

REFERENCES:

1. Johnston, R. and Willey, S. (1995). Proceedings of Helmet- and Head-Mounted Displays and Symbology Design Requirements. SPIE Volume 2465 (pp. 2-13). Bellingham, WA: SPIE.
2. Kollin, J. and Tidwell, M. (1995). "Optical Engineering Challenges of the Virtual Retinal Display." Proceedings of the SPIE, Volume 2537 (pp. 48-60). Bellingham, WA: SPIE.

OSD96-010TITLE: Fiber Optic Bragg Grating Corrosion Monitoring System

OBJECTIVE: Develop a Fiber Optic Tap Bragg Grating Corrosion Monitoring system capable of detecting the occurrence of corrosion in key structural components and monitoring its evolution and severity.

DESCRIPTION: Stress-corrosion cracking and corrosion fatigue are well known to significantly reduce the life expectancy of structures. Development of a monitoring system, which can reliably and accurately detect the amount of corrosion experienced by a structure, would permit early and economical repairs to extend structure life. The main components of the sensor type solicited by this topic will be a fiber optic tap Bragg grating and a fiber coating containing an electrochemical active specie that changes one of its optical properties in the presence of corrosion byproducts.

PHASE I: Fabricate a proof of concept tap Bragg grating coated with an electrochemical active material. Monitor the amount of corrosion in a electrochemical polarization cell.

PHASE II: Develop a prototype Fiber Optic Tap Bragg Grating Corrosion Monitoring system. The optical fiber will have several sensors and the monitoring system will interrogate each sensor independently.

PHASE III: Production and integration of the sensor system into the U.S. Navy aircraft maintenance system.

COMMERCIAL POTENTIAL: A system of this nature has significant potential in the civilian aviation sector for monitoring corrosion in aging aircraft. Such a system could also monitor corrosion in bridges, pressure vessels, and in explosive environments where electrical sensor use might be hazardous.

REFERENCES:

1. Invention Disclosure, "Bragg Grating Corrosion Monitoring System," U. S. Navy Case Number 75942
2. Naval Air Warfare Center Aircraft Division, Warminster Technical Report, Fiber Optic Bragg Grating Model. NAWCADWAR-95027-4.3.
3. Perez, I. et al. "Bragg Grating Corrosion Sensor," Proceedings of the 1994 QNDE Conference. Snowmass, CO.

OSD96-011TITLE: High Platform Speed Sonars

OBJECTIVE: Develop active or passive sonar systems effective at high platform speeds.

DESCRIPTION: Recently developed Navy technology establishes the feasibility of developing practical sonar systems effective at high platform speeds. Such systems, by allowing significantly faster wide area search rates, would benefit a variety of military and civilian applications. The Navy work indicates strong potential for canceling the dominant effect of flow noise on the response of current conformal active or passive sonar arrays for all platform speeds in deep and shallow water. Collectively, the approach is called Magneto-Acoustic Signal Conditioning (MASC). U. S. Patent 5,392,256 was recently issued to the Navy for a MASC sensor. The sensor provides an independent measure of the noise due to turbulent flow but does not interfere with the acoustic signal. As such, the MASC sensor can be used as an ideal reference for an adaptive filter that can perform flow noise cancellation. Measurements at various flow rates in a laboratory tank setting show that signal coherence increased with an increased flow rate, suggesting a 20 dB processing gain per sensor may be easily achievable. Through electronic design improvements, a benchtop prototype unit tested in air achieved an additional 30 dB noise rejection while maintaining the same bandwidth. Applied Research remains outstanding in the area of noise processing, electronic and material integration, and conformal array implementation. An issue is whether motion in the wall containing the sensor creates additional electronic field noise due to magnetic movement.

PHASE I: Design and fabricate a small MASC/conformal sonar array assembly and embed it in a Navy hydrodynamic tow body. Demonstrate acoustic interaction of the modified conformal array with respect to a fixed acoustic source at various low frequencies in a sea test.

PHASE II: Determine the least number of sensor elements required to perform specified search tasks. For one task, design, fabricate, and test at sea a completely integrated and full scale prototype MASC/sonar system.

PHASE III: Transition into a Navy Advanced Technology Demonstration (ATD) program and into civilian applications.

COMMERCIAL POTENTIAL: The technology is relevant to any salt or brackish water acoustic measurement system limited by flow noise. Examples include: geophysical investigations; marine prospecting; underwater object search, detection, and avoidance; fish population surveys; topological surveys.

REFERENCES:

1. R. G. Kasper and A. B. Bruno, U. S. Patent 5,392,256, "Magneto-Acoustic Signal Conditioner," "Magneto-Acoustic Signal Conditioner," February 21, 1995.
2. A. B. Bruno and R. G. Kasper, United States Patent 4,848,146, "Electromagnetic Turbulent Velocimeter," July 18, 1989.
3. R. G. Kasper, A. B. Bruno, and L. Langston, "Preliminary Underwater Electromagnetic Turbulence Measurements," Naval Undersea Warfare Center (NUWC) Division, Newport (formerly Naval Underwater Systems Center) Technical Document. 8909, June 19, 1991.
4. A. B. Bruno, R. G. Kasper, and B. Towe, "Development of an Underwater Electromagnetic Velocimeter," NUWC Division, Newport Technical Document 10065, June 16, 1992.
5. McDowell, D .J., R. G. Kasper, and A. B. Bruno, "Preliminary Electro-Magnetic/Acoustic Signal Processing Techniques to Reduce Flow Noise," NUWC Detachment, New London Technical Memorandum 931088, July 28, 1993.
6. Langston, L. S. and R. G. Kasper, "Analysis of an Electromagnetic Boundary Layer Probe for Low Magnetic Reynolds Number Flows," Jour. of Fluids Eng. Vol. 115, pp. 726-731, 1993.
7. R. G. Kasper and L. S. Langston, Patent Pending, U. S. Navy Case Number 73185, "Electrode Array Electromagnetic Velocimeter," April, 1993.
8. T. Rydzaj, "Improved Electromagnetic Flow Electronics for the Magneto-Acoustic Conditioner (MASC) Sensor," NUWC Division, Newport Technical Memorandum 941097, in publication.

OSD96-012TITLE:Rotorcraft Model Enhancements to Support Land and Sea-Based Testing and Operational Analysis

OBJECTIVE: To develop enhancements to a finite state dynamic inflow model to address rotorcraft cross coupling and vortex ring state conditions for land and sea-based operations.

DESCRIPTION: Accurate full-flight simulation models are required to support flight testing, especially in high pilot workload tasks like the rotorcraft shipboard landing scenario. Improved models for aircraft off-axis coupling and response to vortex ring flight conditions in normal or degraded flight control system status are needed to enhance routine or emergency condition training. One such model, the finite state dynamic inflow model, represents a major advance in rotorcraft simulation technology. This model allows the user to represent the radial and azimuthal inflow distribution with series approximations that are tailored to the required level of accuracy. Due to the computational efficiency and accuracy of this approach, the finite state dynamic inflow model is becoming widely used in rotorcraft simulation. However, it does not provide the ability to model wake deformation in a transient maneuver. As with other free vortex wake models, it is limited to steady state wake deformation and cannot address transient wake deformation. Dynamic wake distortion in a transient maneuver has recently been postulated as a potential cause for the lack of off-axis correlation of simulation results with flight test data. A vortex wake study has demonstrated the ability to improve correlation in a hover. A parameter identification approach has been used to capture the transient response by identifying an aerodynamic phase angle that is tuned to improve off-axis correlation with experimental data. The ability to model transient wake deformation analytically as an extension of the finite state dynamic inflow methodology would inherently address the source of off-axis correlation while providing a more computationally efficient approach than a vortex wake model and a more global and robust representation than a semi-empirical model tuned to experimental data. Dynamic wake deformation is also needed to model the vortex ring state. This state is caused by a concentration of vortex rings at the rotor during descending flight and may be predicted as a direct consequence of the dynamic wake deformation and vortex decay. The analytical basis of the proposed effort should address the full flight envelope, not just at hover.

PHASE I: Review all previous related work involving the finite state dynamic inflow model applications and limitations, rotorcraft off-axis coupling modeling and vortex ring state modeling. Develop a comprehensive plan for including wake deformation effects in a finite state dynamic inflow simulation model, including software development and comparison with free vortex wake results.

PHASE II: Develop the enhanced finite state dynamic inflow model and integrate it into a comprehensive simulation that can be used to support land and sea-based flight operations. Validate the resulting coupled simulation model against free vortex models and experimental test data for a variety of conditions. Evaluate the ability to model the vortex ring state and improve off-axis correlation to transient response with the model. Demonstrate the ability to utilize the finite state dynamic inflow with wake distortion in real-time simulation will be demonstrated.

PHASE III: The model enhancements should result in interest from the Navy, Army, Air Force Special Ops, Coast Guard, FAA, and commercial helicopter manufacturers.

COMMERCIAL POTENTIAL: The enhanced finite state dynamic inflow model, with wake distortion, can be marketed as a stand-alone product for incorporation with a variety of commercial simulation codes or can be combined with a specific comprehensive simulation code to enhance its utility and marketability.

REFERENCES:

1. Peters, D.A., and He, C.J., "Finite State Induced Flow Models Part II, Three Dimensional Rotor Disk," Journal of Aircraft, Vol 32 #2, March-April, 1995.
2. Rosen, A. and Issur, A., "A New Unsteady Aerodynamic Model of the Coupled Rotor-Body Dynamics," 51st American Helicopter Society Annual Forum, Forth Worth, Texas, May, 1965.
3. Fletcher, Jay, "Identification of Linear Models of the UH-60 in Hover and Forward Flight," 21st European Rotorcraft Forum, St. Petersburg, Russia, Aug. 29-Sep 1, 1995.
4. Wang, Shi-Cun, "Analytical Approach to the Induced Flow of a Helicopter Rotor in Vertical Descent," Journal of American Helicopter Society, Vol. 35, #1, Jan. 1990.

OSD96-013TITLE:Underwater Acoustic Intensity Probe

OBJECTIVE: Produce a commercially viable probe for measuring vector acoustic intensity underwater.

DESCRIPTION: The underwater acoustic intensity probe described in US Patent #5,392,258 (assigned to the US Government) serves as the basis of this topic. The intent of the topic is to take the technology from patent through prototype to development of a commercially viable version of the probe. Acoustic intensity is the time-averaged product of acoustic pressure and vector particle velocity and describes the direction and magnitude of real power flow in an acoustic field. Knowledge of the acoustic intensity can be used to trace the source of radiated sound and can be used to isolate the paths by which sound is traveling. Once the source of the radiated noise is determined and the radiation path is described, various techniques can be applied to reduce or eliminate the sound radiation. The acoustic intensity field also describes the effectiveness with which an acoustic source transfers energy to the water and is a useful tool for optimizing such sources. Conventional measurement of acoustic intensity is performed with a two-hydrophone differencing technique. This technique, because it relies on subtracting two nearly equal signals, is only effective when the signal to be studied is far above the ambient noise level and when standing waves produced by multiple reflections are absent. The intensity probe developed, demonstrated, and patented at the Naval Air Warfare Center (NAWC) Aircraft Division measures the acoustic velocity directly instead of by calculation from the pressure gradient. The direct measurement does not require subtraction to form the gradient and so is effective in far more circumstances than conventional intensity measurement. If the probe can be produced economically and coupled to a measurement system, then it should prove to be a valuable tool in fluid-borne acoustics (it is not limited to operation in water).

PHASE I: Fabricate and demonstrate a prototype intensity probe without support electronics.

PHASE II: Develop and fabricate several production prototypes. Develop test procedures for the probes. Evaluate the acoustic performance and the package integrity (for immersion, for 0□C to 70□C temperature tolerance, for normal handling

shock). Prepare a production plan with versions of the probe suitable for both DoD and commercial applications. Design and fabricate an electronics system for either stand alone probe use or for connection to standard signal analyzer hardware.

PHASE III: Production of the probe and electronics system.

COMMERCIAL POTENTIAL: Potential uses of the probe include: diagnosis of noise radiation from submerged machinery; condition-based maintenance of machinery in ships, pumping stations, and power plants; location of sources of annoyance; mapping regions of man-made noise and disturbance of marine mammals and fish; and measurement of the effectiveness and directivity of underwater sound sources.

REFERENCES:

1. United States Patent #5,392,258, "Underwater Acoustic Intensity Probe," February 21, 1995
2. Gabrielson, T.B., Gardner, D. L., and Garrett, S. L., A simple neutrally buoyant sensor for direct measurement of particle velocity and intensity in water. J. Acoust. Soc. Am. 97 (4), April 1995, 2227-2237.

OSD96-014TITLE:Man Portable Fluxgate Localizer for Magnetic Targets

OBJECTIVE: Develop a man portable, localization system for magnetic targets.

DESCRIPTION: The basis for this topic is a laboratory prototype of a magnetic localization system based on Fluxgate Gradiometer technology. The prototype was developed at the Naval Surface Warfare Center, Dahlgren Division. It requires electronic miniaturization, improved temperature stabilization, reduced power requirement, and enhanced software to serve as a man portable instrument. Most past magnetic sensor research has been directed toward making sensor systems more sensitive to enhance detection range. Many potential applications, however, would benefit more from the ability to perform closer-in standoff localization rather than from increased range. Desired localization ranges for UneXploded Ordnance (OXO) tsargets are 10 feet or grater for larger ordnance (bombs) and 5 feet or more for smaller ordnance (mortar and artillery rounds).

PHASE I: Develop and demonstrate an improved, temperature stable magnetic feedback capability and incorporate it in a reduced height sensor array.

PHASE II: Develop a fieldable prototype capable of man portable performance. The prototype should include all necessary electronics miniaturization and integration as well as improvements to the current software to provide the target's magnetic moment in addition to its location and eliminate all ghost solutions. Additional sensors may be implemented as necessary.

PHASE III: Limited production of the system customized and packaged for specific Navy programs.

COMMERCIAL POTENTIAL: The system's ability to perform standoff localization would find application in the oil industry to locate lost well heads or pipelines. The system would also be suitable for use in locating buried materials including hazardous waste, as well as remotely monitoring vehicular activity.

REFERENCES:

1. "Unique Man-portable, Five-element Fluxgate Gradiometer System" Proceedings, volume 2496 SPIE- The International Society for Optical Engineering 17-21 April 1995, pp 384-395
2. "Magnetic Dipole Localization Using the Gradient Rate Tensor Measured by a Five-axis Magnetometer with Known Velocity" Proceedings, volume 2496 SPIE- The International Society for Optical Engineering 17-21 April 1995, pp 357-367
3. "Three Squid Gradiometer", Applied Physics Letters, Volume 63, 1993, pg 403

AIR FORCE, Phillips Lab

OSD96-015 TITLE:Optical Patternation of Sprays

CATEGORY: Exploratory Development; Aerospace Propulsion and Power

OBJECTIVE: Use laser sheet illumination techniques to quantitatively measure the mass distribution in sprays

DESCRIPTION: Measurement of the mass distribution produced by a spray, or "patternation," is of primary importance in developing Air Force propulsion systems and other spray combustion applications. Typically this is measured by inserting an array of collection tubes into the spray, but this process is intrusive, slow, and can only be applied in cold flow. The Propulsion Directorate at Phillips Laboratory has been developing nonintrusive techniques to perform the same measurements using laser sheet technology. To date, technology has been developed to account for viewing perspective, laser sheet intensity variations, conditions of restricted optical access, extinction of the laser sheet, and extinction of the emitted signal by the spray. In view of the dual use applications described below, the market potential could be large if the various techniques could be optimized and combined into a commercially available instrument. Phillips Laboratory will make this technology available for development and use by small businesses.

PHASE I: Phase I will identify the optimum configuration of a system which will maximize commercial applications.

PHASE II: Phase II will develop, fabricate, and evaluate a prototype system, including user friendly interfaces for non-experts.

COMMERCIAL POTENTIAL: An optical patternation instrument would be marketable to any application utilizing spray combustion. This includes the majority of all land, air, and sea propulsion systems as well as the majority of the worldÆs energy conversion needs. Such an instrument would also be marketable to paints and coatings applications, powder technology applications, drying applications, and a large number of chemical processing applications.

REFERENCES:

1. Talley, D.G., Thamban, A.T.S., McDonell, V.G., and Samuelsen, G.S., "Laser Sheet Visualization of Spray Structure," to appear in an AIAA Progress Series Volume entitled Recent Advances in Spray Combustion, K.K. Keu, ed.

2. Talley, D.G., Verdieck, J.F., McDonell, V.G., Lee, S., and Samuelsen, G.S., "Accounting for Laser Sheet Extinction and Fluorescence Signal Attenuation in Applying PLIF to Sprays," 34th AIAA Aerospace Sciences Meeting and Exhibit, paper AIAA 96-0469, 15-18 January, l996.

OSD96-016 TITLE: Rapid Densification of Carbon-Carbon and/or Ceramic High-Temperature/Lightweight Liquid Rocket Engine (LRE) Combustion Components

CATEGORY: Exploratory Development; Materials

OBJECTIVE: Design and fabricate selected liquid rocket engine combustion components, such as injectors, thrust chambers, and nozzles. The resulting components will be fabricated from advanced materials using state-of-the-art rapid densification techniques and be hot-fire tested at Phillips Laboratory, Edwards AFB.

DESCRIPTION: The Propulsion Directorate of Phillips Laboratory is at the forefront of infusing new materials technology into the very conservative rocket propulsion industry. The high temperature components group is developing carbon-carbon and ceramics densification techniques that will allow LRE components to be manufactured in a matter of days, instead of the several months required with current methods. These techniques are scaleable and will allow near net-shape components to be produced. All of the combustion system components within an LRE must be lightened and strengthened without a loss in engine performance if the DoD is to reach the goals set forth by the Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) initiative.

PHASE I: Perform appropriate analysis and design an appropriate LRE component(s) that takes advantage of the properties of the materials outlined above. Show ability to manufacture components with the chosen materials.

PHASE II: Develop and fabricate the components(s) using rapid densification technology. The component must be suitable for hot-fire testing at Edwards AFB.

COMMERCIAL POTENTIAL: Carbon-carbon and ceramic materials have huge industrial potential in the auto, aircraft, medical and general materials industries. They are strong, lightweight, and heat resistant. They are however, very expensive. Exploitation of these rapid densification techniques will decrease the cost and manufacturing time of these materials, making them attractive for such applications as automotive engines and aircraft brakes.

REFERENCES:
1. Upadhya, K. and Hoffman, W.P. "Densification of Porous Articles by Plasma Enhanced Chemical Vapor Infiltration (PECVI)", US Pat No. 5468357
2. Mochida, I. "Direct Preparation of Mesophase Pitch from Napthalene by the Aid of HF/BF3", Chemistry Letters of the Chemical Society of Japan, l989, p 1893-1896.

Rome Labs

OSD96-017 TITLE:Parallel Optical Memory Interconnects

CATEGORY: Exploratory Development; Electronics

OBJECTIVE: Recently, it has become evident that to meet mass data storage requirements of emerging systems and networks, optical three-dimensional memories will be required and there is currently a massive effort in optical memory development. One issue that is currently limiting the unbounded potential of these systems is the I/O bottleneck. This effort seeks to develop parallel, free space optical memory interconnects that can handle data rates on the order of Gbytes/sec and interface with emerging memory systems.

DESCRIPTION: Technology to be developed include spatial light modulators used as page composers in optical memory schemes, micro-collimating lenses, dynamic focusing optics CCD detectors. Issues to consider include data formats and data transfer to and from a host processor.

PHASE I: During Phase I of this effort, the contractor will develop and demonstrate proof of concept for an optical interconnection device capable of I/O functions interfacing optical memory with electronic CPU.

PHASE II: Phase II will demonstrate the operation of this interconnection and investigate technical aspects of producing these interconnects.

COMMERCIAL POTENTIAL: Current and future military requirements (intelligence networks, image libraries, virtual reality training systems, etc.) and civilian requirements (large database storage, medical records and telemedicine, video on demand, digital television) ensure the dual use potential for any high bandwidth data transfer systems.

REFERENCES:
1. RL-TR-95-25, "Optical Volume Storage Interconnects", L. Domash and A. Nelson., Foster-Miller Inc. 1995.
2. RL-TR-92-127, "Active Holographic SLM for Optical Interconnects", L. Domash and J. Schwartz, Foster-Miller Inc. 1992.
3. RL-TR-94-11, "Vibration Insensitive Reconfigurable Optical Interconnects"; A. Nelson, Gozewski, and L. Domash; Foster-Miller Inc. 1994.
4. RL-TR-94-45, "Free Space Parallel Optical Memory Interconnect"; M. Derstine, J. Goodman; Optivision Inc. 1994

OSD96-018 TITLE:Optical Memories

CATEGORY: Exploratory Development; Electronics

OBJECTIVE: Rome Laboratory is investigating the use of photonic technology in advancing the state of the art in data storage. Optical memories show promise in many areas of the data storage hierarchy. Applications include:
archival storage, random access memory, read only memory, cache memory, and associative (content addressable) memory. Three dimensional optical memory offers the potential of terabit storage in volumes on the order of a cubic centimeter. High data transfer will be crucial for military applications as well as civilian uses.

DESCRIPTION: This initiative is directed towards exploiting the "optical Advantage" of storing digital data in the form of optical volume or 3-dimensionally. Concepts such as content addressable memory either numerical, textural, or image identification techniques can be implemented in memory, results isolated, and effectively provide acceleration of output speed and access time. Correlation, auto-correlation, and change detection concepts within the memory itself should also be exploited.

PHASE I: Identify and characterize candidate media, lens architectures, or beam steering concepts to provide storage capacities of 10E10-10E12 bits per cubic centimeter, or at least l0E3-10E6 discrete locations per centimeter.

PHASE II: Incorporate these concepts into a usable architecture and demonstrate feasibility via brassboard.

COMMERCIAL POTENTIAL: Imagery exploitation would be greatly enhanced by the development of faster storage devices, not to mention the benefits of terabit of data accessible at any instant. Medical data will benefit from the advancement of these technologies as well. Imagine your entire medical history available to a physician in another town should medical attention be necessary away from home. A library of X-ray files stored digitally that not only are available on demand, but, now that images are stored digitally, a computer would assist the doctor in detecting tumors earlier than would have been possible before. The development of the "Information Superhighway will hinge on the development of memory systems capable of storing more data than ever before, as well as transferring that data faster than ever before.

REFERENCES:
1. J. Ford, S. Hunter, R. Piyaket, Y. Fainman, S. Esner; "Write/Read Performance in 2 Photon 3-D Memories"; SPIE Proceedings, Photonics for Processors, Neural Networks, and Memories; Vol 2026, pp 604, July 1993.
2. D. Parthenopoulos, P. Rentzepis; "Three Dimensional Optical Storage Memory", Science 245, pp 843-845, 1989.
3. E. Maniloff, S. Altner, S. Bernet, F. Graf, A. Renn, U. Wild; "Spectral Hole Buurning Holography in Optical Memory Systems"; SPIE Proceedings, Photonics for Processors, Neural Networks, and Memories; Vol 2026, pp 592, July 1993.
4. P. Marchand, A. Krishnamoorthy, P. Harvey, G. Yayla, S. Esner; "Motionless-Head for Parallel Readout Optical Disk for Optoelectronic Content Addressable Memory System", SPIE Proceedings, Photonics for Processors, Neural Networks, and Memories; Vol 2026, pp 653, July 1993.

Wright Lab

OSD96-019 TITLE:High Efficiency Cryogenic Power Conversion

CATEGORY: Exploratory Development; Aerospace Propulsion and Power

OBJECTIVE: To employ recent developments in cryogenic power conversion in a commercial demonstration of a megawatt class power convertor/motor controller that can reduce weight and volume by a factor of 10 while operating at increased efficiency and reliability. The innovative technology to be employed includes adaptation of commercial MOS-FET semiconductor switches to cryogenic conditions, commercialization of cryogenic capacitors, and commercialization of high temperature superconducting and cryogenic aluminum inductors. Small l00kW power convertors employing these conditions have already been demonstrated under cryogenic conditions and 2 kilojoule inductors have already been demonstrated using both high temperature superconductors and aluminum conductors.
None of the required components are available on-the-shelf, but all are ready to be developed to proceed to commercialization Phase III in megawatt class power convertor/motor controllers.

DESCRIPTION: Specific technology to be developed includes processing of large quantities of ceramic capacitors, demonstration of 10 kilojoule inductors and cold plate mounting and demonstration of high current MOS-FET switches at 6 to 8 times the current allowed by room temperature operation.

PHASE I: Component demonstrations of capacitors, inductors and MOS-FET switched will be conducted in Phase I. In addition, Phase I will provide a preliminary design of a megawatt class power convertor/motor controller.

PHASE II: Phase II would complete the evaluation and assessment of cryogenic capacitors and MOS-FETs. Phase II will provide the final design, fabrication and test of a megawatt class cryogenic power convertor/motor controller with a goal of less than 0.05 kg/kW.

COMMERCIAL POTENTIAL: The private sector benefit of the demonstration of a megawatt cryogenic class power convertor/motor controller is broad and would include uninterruptable power convertor systems, adjustable speed controllers for large industrial motors, static volt ampere reactive (VAR) compensators for commercial utilities, high current rectifiers for metal and electrolysis plants and power convertors and motor controllers for railroad locomotives and high speed passenger trains. The technology benefit on the military side is critical and provides enabling technology for high power convertors for deployable bare base power, mobile ground based radars, advanced airborne radar surveillance, airborne laser and high power microwave weapons and mobile drive systems for electric tanks, ships and other vehicles. Farther out technologies for which cryogenic power convertors/motor controllers will be essential include magnetically levitated and electromagnetically driven high impact test sleds and space launchers. The military systems will receive major benefit from the tremendous weight and volume reduction potential offered by cryogenic power convertor/motor controller technology at high power levels. The reduction in weight is accompanied by increased efficiency and reliability with good potential for cost reductions. The commercial sector will, of course, benefit from all the technological improvements provided by cryogenic cooling. Commercial annual market projections for the annual global market for power convertors >100kW is $200M.

REFERENCES:

1. Blanchard, R., "Designing Switch-Mode Power Convertors for Very Low Temperature Operation," Proceedings Powercon 10 (1983) D2,1-11.
2. Mueller, O., "On Resistance, Thermal Resistance and Recovery Time of Power MOSFETS at 77K," Cryogenics, Vol 29, #10, Oct 1989, pp 1006-1014.
3. Severns, R., "Superconductivity and Low-temperature Power Convertors," Powertechnics Magazine (1988) 4,p.32-34.
4. O. Mueller, "Properties of High Power Cryo - MOS-FETs," Proceedings of the 27th Power Electronics Specialists Conference (PESC-96), 24-27 June 1996, Baveno, Italy.
5. American Superconductor Corp. Publicity Release, Westborough, MA, 8 November 1995, "American Superconductor Successfully Demonstrates Commercial-Scale Prototype Power Convertor," (617-932-1122).

OSD96-020 TITLE:Smart Sensors Using Fiber-Optics and Distributed MEMS (Microelectromechanical Systems)

CATEGORY: Exploratory Development; Materials

OBJECTIVE: Develop and demonstrate the technology for connecting and multiplexing large numbers of microdevices, such as sensors and actuators for structural monitoring or smart structural control, using fiber-optic technology.

DESCRIPTION: Numerous applications of interest exist for structures, surfaces and materials whose shape, mechanical properties, or functional behavior can be altered in real-time response to changing conditions without explicit external command. Examples are:

A) Wing spars which can become stiffer in different directions depending on the direction of primary loadingB) Smart wing skins containing arrays of microdevices which can control boundary layer separation and buffet-induced vibrations at high angles of attach

C) MEMS to increase the effectiveness of flight control surface trailing edges

Key to implementation of such structures is the ability of an automated system to interconnect, address and control large numbers of distributed sensing and actuation elements. Depending on the application, these may be pressure sensors, shear stress sensors, temperature sensors, microflaps, linear actuators, miniaturized hydraulic actuator valves, or other devices. Fiber-optics technology shows promise for this application in that large numbers of devices can potentially be multiplexed along single fibers, and the fibers may be easily integrated with structures, particularly fiber-based composites. The techniques for achieving good connections between several devices and a single fiber, and for assuring effective communication with/between these devices, need to be matured.

Proposals may be targeted toward any one or all of the above application areas.

PHASE I: Develop and demonstrate the ability to connect several discrete devices along the length of an optical fiber so that communication with each device is possible.

PHASE II: Demonstrate a prototype system for gathering signals from a large number of distributed devices arranged along optical fibers, and sending signals back to individual devices in response to the collected signals. This prototype system will be suitable for use in a smart structure, flight control, aerodynamics or structural monitoring demonstration.

COMMERCIAL POTENTIAL: The maturation of this technology will allow the low-cost monitoring, and eventual smart structural control, of civil structures such as bridges and buildings, marine structures such as off-shore platforms, as well as civilian aircraft, spacecraft and other complex structural systems.

REFERENCES:

1. Mehregany, M. and Bang, C., "MEMS for Smart Structures," Proc. of SPIE Conf.Smart Struct. and Matls. Feb 26-March 3, 1995.

2. Claus, R., Sherrer, D., and Weng, A., "optically Based, Micro-Integrated Materials and Structures," Proc. of Micro-Integrated Smart Matls. and Struct. Conf., Soc. for Experimental Mechanics, Sept. 1995.

3. Jacobson, S.A. and Reynolds, W.C., "Active Control of Boundary Layer Wall Shear Stress Using Self-Learning Neural Networks," AIAA 93-3272, 1993.

Technical Transition Office

OSD96-021 TITLE:Small Lot Repair/Manufacture of Microcircuit Boards by Laser Deposition

CATEGORY: Engineering Development; Electronics

OBJECTIVE: Develop a real-time, computer controlled laser capable of the precision deposition of metal on a variety of substrates.

DESCRIPTION: Metal may be deposited on a variety of materials including plastic, glass, and ceramic by thermal breakdown of metal halide gases. The metal halides typically have a decomposition temperature ranging from 350 degrees F to 650 degrees F. It is intended that a laser be utilized to produce the required heat. The heat pattern would be localized on a microscopic basis with a width and depth dependent upon the laser source. The localized heating would not be expected to damage the substrate material. The chemical vapor deposition and laser technology associated with this project is established. The intent will be to place the laser under real-time computer control or manual control whereby the beam may be directed to a precise location. In the case of an assembled microcircuit board, the objective would be to create new traces without disassembly. Disassembly frequently damages the components which may no longer be available. The process is also directed at the economical

manufacture of small lots of new boards. The real-time computer allows data to be input and then the traces applied directly to the subtrate.

The number of passes made by the laser will determine the depth of metal deposition, trace width and pattern. The project will eliminate many of the costly and defect prone phases of microcircuit board processing. The device will also have the capability to repair its own defects.

PHASE I: Conduct a technical analysis of microcircuit boards determining the necessary unit specifications for the laser deposition device. Analysis will include definition of laser type, halide compounds to be utilized, environmental hazards, accuracy of beam control, and chamber materials and construction. An economic analysis will also be required of the cost to produce the unit, operating costs thru put and return on investment. A detailed analysis and preliminary design shall be provided of the laser deposition unit.

PHASE II: In this tasking a prototype computer controlled, laser deposition unit shall be constructed. The unit shall be capable of accommodating assembled or bare boards up to 2 feet in major dimension. The ability to repair assembled boards and to create new boards from drawings shall be demonstrated.

COMMERCIAL POTENTIAL: The production of small lots of microcircuitry boards is frequently undesirable to industry. This results in the scarcity of manufacturing sites and frequently high costs for those boards that are produced. This subject unit would eliminate the risk and setup costs associated with small lots. The unit would be adaptable to virtually any manufacturer of electronic wire boards/microcircuit boards. It is particularly significant to those organizations doing microwave or gold ceramic.