ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

ARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the ARPA 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.

ARPA has identified 44 technical topics, numbered **ARPA SB961-001** through **ARPA SB961-044**, to which small businesses may respond in the first fiscal year (FY) 96 solicitation (96.1). Please note that 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 ARPA technical offices.

ARPA Phase I awards are limited to **$99,000**. ARPA Phase II proposals must be invited by the respective Phase I technical monitor. Phase II proposals are encouraged at the amount of $375,000; however, additional funding may be available for optional tasks, for a total contract value not to exceed $750,000.

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

ARPA/OASB/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 696-2448

The proposals will be processed by ARPA OASB and distributed to the appropriate technical office for evaluation and action.

ARPA selects proposals for funding based upon technical merit and the evaluation criteria contained in this solicitation document. As funding is limited, ARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the ARPA mission. As a result, ARPA 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 ARPA must have a topic number and must be responsive to only one topic.

A checklist has been prepared to assist small business activities in responding to ARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to ARPA. One additional photocopy of Appendices A & B is requested. Do not include the checklist with your proposal.

ARPA 1996 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 ______

   j. Facilities/Equipment ______

   k. Consultant ______

   l. Prior, Current, or Pending Support ______

   m. Cost Proposal (see Appendix C of this Solicitation) ______

   n. Prior SBIR Awards ______

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. ______

4) Submission Requirement for Each Proposal

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

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

c. One additional photocopy of Appendices A and B only. ______

INDEX OF ARPA FY 96.1 TOPICS

ARPA SB961-026	Energy Scavenging for Small Data Collection Systems
ARPA SB961-027	Magneto-Rheological (MR) Fluids, Devices, and Applications
ARPA SB961-028	Optical Network Switching Technology
ARPA SB961-029	Materials and Process Technologies for Low-Power Semiconductor Circuits
ARPA SB961-030	Maskless Lithography for Microelectronic Devices with Features of 0.1 Microns
ARPA SB961-031	Virtual Prototyping Tools for Semiconductor Fabrication Equipment
ARPA SB961-032	Low-Noise Optical Amplifier
ARPA SB961-033	Development of Techniques to Ruggedize Graded Index Communication Grade Plastic Optical Fiber
ARPA SB961-034	Miniature Environmental Air Sampler for Biological Materials into Fluid
ARPA SB961-035	Detection and Characterization of Underground Facilities (UGF)
ARPA SB961-036	Small Chemical and Biological Agent Sensors
ARPA SB961-037	Video Retrieval Based on Language and Image Analysis
ARPA SB961-038	Lightweight, Low-Cost Surveillance Arrays
ARPA SB961-039	Computational Intelligence Approaches to Automatic Target Recognition (ATR)
ARPA SB961-040	Alternate Power Sources for Aerostats
ARPA SB961-041	Rapid Target Model Development and Validation
ARPA SB961-042	Development of Holographic Memory for Use In Optical Correlators
ARPA SB961-043	Non-Linear Optic Materials for Protection of Optical and Electro-Optical Sensors
ARPA SB961-044	Millimeter Wave/Infrared Dichroic Beam Combiner

SUBJECT/WORD INDEX TO THE ARPA FY96.1 TOPICS

ARPA 96.1 TOPIC DESCRIPTIONS

ARPA SB961-001TITLE: Critical Components for Hybrid Electric Power Systems

CATEGORY: 6.2 Exploratory Development; Electric Power, Pulse Power

OBJECTIVE: Develop and demonstrate system architectures, critical components, and/or component subsystems for hybrid electric power systems.

DESCRIPTION: Research and develop key enabling hybrid electric power system technologies for future combat vehicles. Efforts may address any technology for hybrid electric power systems for which significant leverage can be demonstrated, however, power averaging, conditioning, distribution, and control devices are of particular interest. The focus of this effort is on integrated power systems and not on the development of electrically powered subsystems. Efforts should address an integrated power system or its components, capable of powering multiple loads, such as gigawatt pulse power for weapons and megawatt continuous power for propulsion. Energy density, power density, thermal management, and cost are critical parameters.

PHASE I: Design the system architecture, component, and/or component subsystem for a future combat vehicle hybrid electric power system and demonstrate feasibility through modeling, simulation, virtual prototyping, or laboratory demonstration. Define an approach for full-scale development, including a cost analysis and test plan for validation of performance. Complete documentation of designs and feasibility test results must be delivered.

PHASE II: Develop full-scale prototype and/or subscale prototype with scaling algorithms from Phase I design and implement test plan to validate performance. Evaluate Phase I models, simulations, or virtual prototypes using Phase II test data. Complete documentation of prototype and test results must be delivered. Develop and provide a plan to manufacture the developed prototype.

COMMERCIAL POTENTIAL: The development of critical components for hybrid electric power systems will expand commercial markets for the growing light and heavy-duty electric and hybrid vehicle industry; support the electrical utilities in power load leveling, uninterruptable power supply, and power distribution; enable enhanced safety and control for aircraft with electric actuators and high temperature power electronics; support space station power distribution systems; and electric drive ship systems. Realize significant cost reductions due to dual-use high volume production and component scalability.

REFERENCES:
1) "Future Combat Vehicles Hybrid Electric Power Briefing," Advanced Research Projects Agency, 195. Requests for these viewgraphs should be directed to (703) 696-2448.
2) Institute of Physics Conference Series Number 141, "Proceedings of the Twenty-First International Symposium on Compound Semiconductors," held in San Diego, California 18-22 September 1994.
3) Scientific American, "High-Power Electronics," November 1993.
4) National Research Council, STAR 21: Strategic Technologies for the Army of the Twenty-First Century, ISBN 0-309-04629-7, National Academy Press, 1992.
5) Rodler, W. E., Shafer, K. W., "Electric Drive Study," U.S. Army Tank Automotive Command, Contract DAAE07-84-C-R017, December 1987, DTIC AD Number: A255058.

ARPA SB961-002TITLE: Improved Representation of Human Behavior in Simulation

CATEGORY: 6.2 Exploratory Development; Modeling and Simulation

OBJECTIVE: Create realistic Artificial Intelligence (AI) technologies to realistically represent human behavior.

DESCRIPTION: Current representation of human behavior in simulation is still rudimentary, based largely on simple rule sets. ARPA is seeking AI technologies which will allow improved representations of this behavior at a reasonable cost in terms of computing resources. Solving this requirement is fundamental to the improvement of simulation throughout DoD.

PHASE I: Design and execution plan for a prototype of human behavior in computer generated forces.

PHASE II: Create a prototype in a service specific mission area.

COMMERCIAL POTENTIAL: There is significant potential within civilian industry, particularly the entertainment industry, for the use of this technology. Creating technologies that enhance a computer's ability to emulate human behavior has applicability in all areas of civilian industry.

REFERENCES:

1) Garrett, R. 1995. "ADS: Looking Toward the Future." *Phalanx,* June, 1995, 9-11.

2) Hayes-Roth, B. 1993. "On Building Integrated Cognitive Agents: A Review of Allen Newell's Unified Theories of Cognition." *Artificial Intelligence 59:329-341.*

3) Laird, J.E.; R.M. Jones; and P.E. Nielsen 1994. "Coordinated Behavior of Computer Generated Forces in TacAir-Soar." In the Proceedings of the Fourth Conference on Computer-Generated Forces and Behavioral Representation, 325-332/ Orlando, Fl.: University of Central Florida Institute for Simulation and Training.

4) Nelson, G.; Lehman, J.F.; and John, B.E. 1994. "Integrating Cognitive Capabilities in a Real-Time Task." In *Proceedings of the Sixteenth Annual Conference of the Cognitive Science Society.* Hillsdale, N.J.: Lawrence Erlbaum.

ARPA SB961-003TITLE: Ultra-High Performance Antennas for Communications-on- the-Move (COTM)

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications

OBJECTIVE: Design, develop, and test ultra-high performance antennas in support of communications-on-the-move (COTM) for airborne and ground platforms.

DESCRIPTION: The military is in the process of developing programmable, multiband, multimode radios that provide multiple, simultaneous transmit and receive channels in the frequency range of 2 MHz to 2 GHz to support the digitization of the battlefield. New, advanced ultra-wideband antenna concepts, subsystems and components that support multiple, simultaneous transmission and/or reception need to be developed to exploit advanced radio capabilities, such as reprogrammability and frequency agility.

Ultra-widebeam antennas are required to provide communications capabilities using a high altitude endurance (HAE) unmanned aerial vehicle (UAV) and mobile ground platforms. These capabilities include broadband relay services and broadcast services for dissemination of wideband digital information. UAV antennas with ultra-wide beamwidths increase the coverage area to enable COTM and simplify payload design. Ultra-widebeam antennas in ground platforms provide COTM capability, ensure rapid access of service and simplify ground terminal design. Multimode operation supports beamwidth expansion and may provide simultaneous and/or switched multifunction operation in support of multiple communications system requirements.

PHASE I: Identify concepts/approaches for ultra-wideband and ultra-widebeam antennas, subsystems, and components. Define trade space for ultra-wideband antennas. Identify trades for performance capabilities versus beamwidth of ultra-widebeam antennas, including simultaneous and/or switched multimode, multifunction operation. Develop range of baseline designs based on trade studies. Define Phase II approach.

PHASE II: Fabricate the selected ultra-wideband and ultra-widebeam antennas/subsystems. Obtain complete characterization of the antennas and demonstrate performance.

COMMERCIAL POTENTIAL: Ultra-wideband antennas will support simultaneous communications on a variety of commercial communications systems, such as cellular, personal communications systems and Mobile Satellite Systems (Iridium). The multimode, multifunction, ultra-widebeam antenna has significant commercial potential for COTM applications, including mobile SATCOM, cellular and broadcast services. Multifunctionality will result in reduced costs, size, and weight, all of which benefit commercial systems in addition to promoting solutions to technical issues (co-site interference, etc.).

REFERENCES:
Strugatsky, Alexander and Dr. C. H. Walter, "Multimode Multiband Antenna", Proceedings of the Tactical Communications Conference, Fort Wayne, IN, 28, April 28-30, 1992.

ARPA SB961-004TITLE: Collaborative Tools for Building Virtual Worlds

CATEGORY: 6.2 Exploratory Development; Modeling and Simulation

OBJECTIVE: Create collaborative tools and processes capable of linking disparate source materials, diverse domain knowledge, and interdisciplinary experts, at specialized workstations in distributed systems, to support efficient generation of 3-D virtual worlds for modeling and simulation applications.

DESCRIPTION: Research and development leading to collaborative tools to link disparate source materials and diverse domain knowledge for efficient generation of 3-D virtual worlds supporting modeling and simulation applications. It is anticipated that proposals will incorporate capabilities of computer aided design workstations, digital map data repositories, expert systems, geographic information systems, and softcopy image exploitation workstations in distributed systems linked by local and wide area networks. Such capabilities can link interdisciplinary teams which may include cartographers, simulation data base modelers, terrain analysts, and application specialists representing the end user. Military applications include training, analysis, situational awareness, mission planning, and mission rehearsal. The technology needs to be adaptable to support diverse military applications ranging from theater-level operations by a Joint Task Force, to special operations conducted by individual combatants at the appropriate levels of resolution and detail.

PHASE I: Design distributed system concepts, architecture, and processes needed to link disparate source materials, algorithms, domain knowledge, and experts, with collaborative tools for spatial data integration, to create geospecific virtual worlds. Specify a lossless approach to interchange the assembled virtual world with external applications such as real-time visualization and synthetic forces in Advanced Distributed Simulation. Design and assemble source materials for one or more test cases.

PHASE II: Implement and demonstrate a distributed system, linking disparate source materials, algorithms, domain knowledge, and experts, with collaborative tools for spatial data integration, to create geospecific virtual worlds. Use a lossless interchange mechanism assembled virtual world with external applications to include real-time visualization on multiple platforms and synthetic forces in Advanced Distributed Simulation. Complete documentation of test cases and results must be delivered.

COMMERCIAL POTENTIAL: The development of flexible, adaptive capabilities to create geospecific virtual worlds, integrating digital map data, all-source imagery, and domain-specific expertise, will expand the commercial market to address a broad spectrum of military, architectural, land use planning, and entertainment applications. Potential commercial products hold the promise for generating higher quality digital terrain models with dramatic reductions in the time required.

REFERENCES:
1) Paul Birkel, Carol Chiang, Steve Farsai, Farid Mamaghani, David Pratt, and Joshua Smith. "Synthetic Environment Data Representation and Interchange Specification (SEDRIS)." In 12th Workshop on Standards for the Interoperability of Distributed Simulations, Institute for Simulation and Training, March 1995.
2) DIS Vision Document, Technical Report IST-SP-94-01, Institute for Simulation and Training, May 1994. (available via WWW, see address below)
3) DoD Modeling and Simulation Master Plan, Defense Modeling and Simulation Office, Alexandria, VA, 1995. (available via WWW, see address below)
4) Synthetic Environments Data Representation Interchange Specification (World Wide Web: http://www.dmso.mil/).

ARPA SB961-005TITLE: Novel Techniques to Deflect Bullets for Body Armor and Helmets

CATEGORY: 6.2 Exploratory Development; Personal Survivability Systems

OBJECTIVE: Develop extremely lightweight materials and designs, which will protect individuals through deflection of bullets, as compared to today's heavyweight concepts of protection through stopping the bullet.

DESCRIPTION: Research and development leading to the design of extremely lightweight body armor, extremity armor, and helmets that protect the individual through bullet deflection instead of stopping the bullet. Current standard military (approx 9 lbs) vests were designed to stop fragments, not rifle bullets. Approximately two million of these vests have been produced. Bullet protection is now desired. Current state-of-the-art methods involve heavy plates (up to 10 lbs/square foot) to stop 7.62mm armor piercing (AP) bullet threats. Substantial R&D efforts exist to reduce the weight to 5.5 lbs/square foot. This weight is viewed as the lower limit to stop AP rounds and is still too heavy to provide substantial body coverage for the user. The proposed R&D effort seeks materials, ballistic designs, and configuration, such that bullets can be deflected away from the individual through the combination of obliquity surfaces the soldier presents in his fighting positions (standing and prone). Extremity configurations should weigh between 1.5 to 2.0 lbs/square foot. Designs should minimize interference with the soldier's motion. Total designs should be between the weight of the current flack vest, 9 lbs, and Ranger body armor of 18 lbs. Helmet designs should be within the weight of the current helmet (3.3 lbs). Surface coating techniques should also be examined. PHASE I: In detail, define, design, and test ballistic flat plate samples at oblique angles, representative of angles a soldier presents in a standing and prone fighting position. Present full system concept designs for integration on to the individual, complete with weight estimates, ballistic coverage, ballistic holes, and bullet deflection paths.

PHASE II: Design and build four systems of one or more designs for ballistic and user testing.

COMMERCIAL POTENTIAL: Body armor markets are substantial for military and law enforcement agencies. Commercial use could extend to security guards, special persons protection, and private citizen use.

ARPA SB961-006 TITLE: Graphical Visualization of Cyberspace

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Develop capabilities for intelligent graphical browsing and retrieval tools that will allow users to effectively browse the vast amount of information available in Cyberspace.

DESCRIPTION: The explosion of information available on the Internet has resulted in a significant problem of user interface -how can users browse such information to find items of interest? The goal of this effort is to develop capabilities for intelligent graphical browsing and retrieval tools that will allow users to effectively browse the vast amount of information available in Cyberspace. These tools will exploit both the advances in graphical techniques for dealing with large data sets, as well as methods (i.e., World Wide Web) that allow for the integration of disparate networked information. Possible technologies and example products include, but are not limited to, the following: 1) generic and domain-specific methods for representing information in 3-D models suitable for rendering and visualization, 2) methods for gathering specified subsets of data from Cyberspace and providing access through graphical visualization, and 3) tools that implement the above and support graphical browsing of the Internet. The visualization paradigms should be able to deal with both information that has natural physical models as a basis for visualization, as well as more abstract information that has no natural physical model.

PHASE I: In detail, define and do a preliminary demonstration of techniques that will support intelligent graphical browsing.

PHASE II: Develop a prototype system that implements the techniques defined in Phase I, and conduct sufficient user testing to validate the approach. Complete documentation of test cases and results must be delivered.

COMMERCIAL POTENTIAL: Development of sophisticated graphical browsing techniques will increase the commercial value of information on the Internet and result in an increased commercial market for such information. It will also permit a wider set of users to access and utilize such information.

REFERENCES:
Online information through http://www.csto.arpa.mil and http://www.hpcc.gov

ARPA SB961-007 TITLE: Security in Workflow Processes

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Explore and develop innovative reference implementations for the enforcement of various, composable, domain-oriented, workflow security policies, and encourage such investigations specifically for medical record administration and handling, and manufacturing.

DESCRIPTION: Workflow processes control what information will be processed by which individual person, tool, program, and/or machine, and the timing of that processing. The processes may be demand-driven and/or supply-driven. The flow may be information to be worked on (e.g., documents), it may be tokens (e.g., authorizations or obligations) that enable or mandate process actions along with a reference to the work item, or it may be both token and information. The controls may be distributed to each processing element or linked through an application (workflow) framework that controls interactions to underlying persistent objects. Such controls are vulnerable to disruption if their security is not built into their design and implementation. However, achieving such security poses unique workflow design requirements in dealing with the domain-specific information life-cycles, information ownership, provenance, origination, usage, roles, authentication, authorization, access, release, integrity, availability, confidentiality, privacy, sharing, inference, storage, retrieval, transmission, retention, auditing, and security administration. Protection, in the workflow context, must consider the use of general purpose applications as well as domain-specific applications.

Investigation efforts which include small teams of workflow, domain-specific, and security expertise are encouraged. Innovations should include workflow-control protection enforcement via protocols, or by application programming interfaces to underlying protection mechanisms; considered use of multi-function smartcards; incorporation of satellite and wireless operations; and protection incorporated across the infrastructure of a large-scale distributed system. Such innovations should strive to produce a level of trust and robustness that reduces the required amount of overall system assurance evaluation (e.g., through the use of reusable, composable, and interoperable modules and/or security protocols that support workflow concepts). Innovative solutions to such requirements will properly integrate and/or link common core and extendible elements of security policy enforcement mechanisms. Such security policies should have components that are enforced system wide, and components that are user settable. Particular attention should be paid to design issues to ensure that controls cannot be thwarted or bypassed in unauthorized ways.

PHASE I: Conduct a six month study that develops and validates a distributed system model of workflow security within the medical or manufacturing domain. Such a model should cover the entire lifecycle of information within the domain. Demonstrate, through the model, how security policies may be composed, modified, and extended to meet changes in workflow processes. Provide an initial assessment, based on the model, of the scalability and cost of security management associated with workflow protection in large-scale systems. Perform a general assessment of security support provided by current workflow development tools and frameworks available to support the model.

PHASE II: Design and prototype the modeled secure, distributed workflow system. Confirm the resulting utility and security of the system within the model's domain (e.g., hospital, clinic, or manufacturing floor). Confirm previous assessments developed in Phase I through experimental tests with the prototype system within the domain. Demonstrate adaptability and extendibility of the prototype. Demonstrate documented assurance associated with the design and development of the prototype.

COMMERCIAL POTENTIAL: This technology is directly applicable to enhancing the productivity in both military and civilian domains.

REFERENCES:
1) D. D. Coleman (ed.), Groupware 92, San Mateo, CA, Morgan Kaufmann Publishers, Inc., 1992.

2) D. D. Clark and D. R. Wilson, "A Comparison of Commercial and Military Security Policies," Proceedings 1987 IEEE Symposium of Security and Privacy, pp. 184-194, CS Press, Los Alimitos, CA, 1987.
3) P. C. Clark and L. J. Hoffman, "BITS: A Smartcard Protected Operating System," Communications of the ACM, Vol. 37, No. 11, pp. 66-70.
4) R. H. Deng, et al, "Integrating Security in CORBA Based Object Architectures," Proceedings 1995 IEEE Symposium of Security and Privacy, pp. 50-61, CS Press, Los Alimitos, CA, 1995.
5) C. A. Ellis, S. J. Gibbs, and G. L. Rein, "Groupware: Some Issues and Experiences," Communications of the ACM, Vol. 34, No. 1, pp. 39-58, January 1991.
6) B. Fairthorne (ed.), "OMG White Paper on Security," OMG Security Working Group, Object Management Group, Framingham, MA, April 1994.
7) K. C. Lee, W. H. Mansfield, Jr., and A. P. Sheth, "A Framework for Controlling Cooperative Agents," IEEE COMPUTER, Vol. 26, No. 7, pp. 8-17, July 1993.
8) J. Linn, "Generic Security Service Application Program Interface," Internet Engineering Task Force RFC 1508, September 1993.
9) D. E. Mahling, N. C. Craven, and W. B. Croft, "From Office Automation to Intelligent Workflow Systems," IEEE EXPERT, Vol. 10, No. 3, pp. 41-47, June 1995.
10) John McLean, "The Specification and Modeling of Computer Security," IEEE COMPUTER, Vol. 23., No. 1, January 1990.
11) J. D. Palmer and N. A. Fields, (Guest Eds.), "Computer-Supported Cooperative Work," IEEE COMPUTER, Vol. 27, No. 5, May 1994.
12) R. S. Sandhu, "Lattice-Based Access Control Models," IEEE COMPUTER, Vol. 26., No. 11, November 1993.
13) Richard Schreiber, "Workflow Imposes ORDER on Transaction Processing," DATAMATION, July 15, 1995.
14) M. P. Singh and M. N. Huhns, "Automating Workflows for Service Order Processing: Integrating AI and Database Technologies," IEEE EXPERT, Vol. 9, No. 5, October 1994.
15) M. Spreitzer and M. Theimer, "Scalable, Secure, Mobile Computing with Location Information," Communications of the ACM, Vol. 36, No. 7, page 27, July 1993.
16) J. Vazquez-Gomez, "Multidomain Security," Computers & Security, Vol. 13, No. 2, pp. 161-184, April 1994.

17) T. White and L. Fischer (eds.), New Tools for New Times: The Workflow Paradigm, Alameda, CA, Futures Strategies, 1994.
18) D. M. Yellin and R. E. Strom, "Interfaces, Protocols, and Semi-Automatic Construction of Software Adaptors," Proceedings of OOPSLA-94, Portland, OR, pp. 176-190, ACM Press, October 1994.

ARPA SB961-008 TITLE: Microsystems, Microarchitectures, and Components

CATEGORY: 6.2 Exploratory Development; Computing and Software, Electronics

OBJECTIVE: Achieving the goal of an affordable defense requires leveraging commodity microelectronic components to develop scalable computing and information systems. Existing commodity components are inadequate to meet the demands of defense applications. Specifically, in the critical area of embedded and mobile information systems, the performance of these systems is limited by the power consumed by microsystems components, the gain and efficiency of miniature antenna systems, and the flexibility and adaptation of microarchitectures. This topic solicits innovative research in these focused areas to enhance commercial technologies to meet the needs of Defense.

DESCRIPTION: The performance and applicability of commodity microelectronics components to defense embedded and mobile computing applications is limited by the power consumed by the microprocessor, memory, and communications elements. This topic solicits novel approaches at the microarchitecture level to fundamentally reduce the power consumed by commodity processor-based systems. Techniques proposed should exploit the integrated circuit process level techniques, such as voltage scaling, but should principally focus on circuit, architecture, and system level techniques to bring substantial power savings to computing applications.

A second, but related element solicits techniques for configurable computing that enhance system efficiency and performance across a diverse set of Defense applications. Ideas might include dynamic reconfiguration, adaption to environments, or enhancements for security or reliability that significantly improve system utility. Proposals could address the hardware architecture of configurable components, the system architectures of a configurable system, or the design technology to support this model of computing (e.g. compiler technology). Applications span hand-held mobile computing systems to embedded scalable high-performance computing systems.

The third critical element seeks miniature antenna technology to support dramatic improvements in information rates, range, and user population for distributed wireless information systems. Proposals might address low-cost production methods for microstrip or other planar/conformal antenna structures to significantly improve performance over vertical or dipole elements. Directional antenna approaches that can be integrated into hand-held or portable information system elements are specifically of interest. Applications include digital battlefield and special force.

PHASE I: Design, simulation, and concept phase, with sufficient results to validate the assumptions and quantify the benefits of the approach. Define the metrics to be used in Phase II.

PHASE II: Prototype phase, with functional demonstrations in a systems context to validate the approach and simulation results. Phase II report must include plans to commercialize results of the research and define how the technology will be made available to Defense.

COMMERCIAL POTENTIAL: Elements of an affordable Defense must leverage commercial technology. This topic requests microelectronics technology that leverages and extends the commercial technology base. Power reduction techniques will benefit the hand-held wireless commercial market as well as the personal and portable computer markets. Configurable computing approaches of direct benefit to Defense are likely to be an efficient and low-cost alternative for industrial embedded computing applications such as industrial control. Application of miniature high performance antenna technology will yield technically superior, commercially viable, and widely marketable antenna products for such markets as the rapidly growing personal wireless communication market.

REFERENCES:
Strategic Implementation Plan, Committee on Information and Communications National Science and Technology Council, March 10, 1995. Publication number NCO HPCC 95-02. e-mail contact: nco@hpcc.gov
World Wide Web: ARPA Home Page: http://www.arpa.mil

ARPA SB961-009TITLE: Scalable Software Libraries for High Performance and Embedded Scalable Computing Systems

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Develop libraries suitable for heterogeneous scalable systems (e.g., from a single workstation, to a heterogenous collection of workstations, to a massively parallel processor). Of particular interest is the definition of a set of APIs for the libraries that will be applicable across the entire range of interest.

DESCRIPTION: ARPA seeks research into scalable software libraries that will enable the rapid development of scalable code and its portability across a wide range of scalable systems. This includes integration of library technology, ranging from low-level functions, such as the BLAS, to high-level functions, such as sparse solvers, into scalable HPC languages. In addition, innovative libraries for supporting computation and communication over scalable heterogeneous systems are sought. Topics of interest also include object-oriented class libraries for signal/sonar/image processing for scalable heterogeneous HPC systems. Also of interest in this area is the development of domain specific tools that are also scalable and portable. Examples of such tools are Khoros in the area of image processing. Any tools so developed should exploit existing libraries, such as BLAS, to reduce the development effort and enhance portability.

PHASE I: Requirements analysis, market analysis, approach definition, high-level design and test methodology, documentation, and marketing approach.

PHASE II: Detailed design, implementation, performance analysis and tuning, portability and scalability demonstration, and user and programmer documentation.

COMMERCIAL POTENTIAL: The 2X improvement in processor performance has resulted in users migrating from processor to processor in search of improved performance. At the same time, reductions in cost have necessitated the utilization of the minimal system capable of doing a task with a requirement that additional processing/communication resources will be added as funds develop. Both issues dictate a demand for commercial libraries that are both portable and scalable to meet these challenging demands in a transparent and cost-effective manner.

ARPA SB961-010 TITLE: Security Tools

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Enhance and/or expand the set of administrative, analytical, and diagnostic tools available to security administrators, security auditors, and systems administrators across the spectrum of heterogeneous networked and distributed systems.

DESCRIPTION: Research and development leading to security tools with broad applicability to today's widely fielded, heterogeneous systems. Examples are tools for configuration checking (to ensure a system configuration is secure), intrusion detection (continuous monitoring and detection of suspicious activity), self-test and diagnostics, and penetration analysis (for rapid damage assessment and system recovery). Tools that aid in the selection, collection, reduction, and use of computer and network audit data are vital to intrusion detection and to accountability in after-the-fact reactions to security incidents. Tools to establish timely and cogent anomaly patterns that reflect possible incidents are needed, especially in large-scale, heterogeneous, distributed systems. Some audit analysis tools will be more appropriate for off-line operations, while others are needed to support real-time operations. Novel approaches are desired for tools that will: 1) improve the capture of security-relevant information in real-time with reductions in both system processing overhead and human intervention, 2) reduce the labor-intensive operations associated with incident response, and 3) improve testing of the effectiveness and efficiency of firewall filtering. Proposals must clearly state the analytical methods to be employed, and must include a task that evaluates the success of the methods for the application. Earlier techniques and tools that were taken as far as the proof-of-concept stage may be reused and extended. Proposals to enhance existing tools to make them more broadly applicable will also be considered. The capabilities of these new or enhanced tools should go well beyond what has previously been done. Solutions must be scalable for use in extremely large, heterogeneous computing and communications networks. Special attention must be paid to ease of use and ease of management. Proposals must clearly state the scale of system targeted.

PHASE I: In detail, define the application, the analytical techniques or algorithms to be used, the approach to, and limits of, scalability, and quantify the expected benefits. Produce a detailed design of the tool to be implemented.

PHASE II: Produce a prototype of the tool, its documentation, and an experimental evaluation of its effectiveness. Complete documentation of test cases and results must be delivered.

COMMERCIAL POTENTIAL: The development of scalable, easy-to-use security tools that can be used to analyze very large, heterogeneous, computing and communications systems will help feed the growing market for tools to safeguard systems from attack by insiders or external penetrators, and to help security managers perform their jobs without need for extensive security expertise. These tools can help to establish new markets for security tools and services. For example, tools to check security configuration can be used by a commercial security certification service, and tools for damage assessment and incident recovery can be used by a commercial incident response service.

REFERENCES:
1) "Network Intrusion Detection," IEEE Network, May/June1994.
2) "A Survey of Intrusion Detection Techniques," Computers and Security, 12 (1993).
3) "Firewalls and Internet Security," W.R.Cheswick & S.M.Bellovin, Addison-Wesley, (1994).

ARPA SB961-011 TITLE: Optical Network Security Technology

CATEGORY: 6.2 Exploratory Development; Information Technology

OBJECTIVE: Develop network security technology for the broadband all-optical networks.

DESCRIPTION: Recent advances in optical network technology have demonstrated the scalable bandwidth capability, as well as the data format transparency, i.e., no electronic regeneration, in laboratory optical network testbeds. This solicitation aims to exploit these features of optical network to develop unique optical network security technology for future all-optical network transmission. Potential candidates must be compatible with some of the ongoing or planned DoD optical network testbeds. These testbeds are (or will be) running at 2.48 Gb/s per channel, and may have multiple wavelengths (four to eight).

PHASE I: Effort should emphasize the demonstration of the basic unique idea either in the laboratory, or by simulation and modeling.

PHASE II: Effort should be a more elaborate demonstration at an appropriate DoD network testbed.

COMMERCIAL POTENTIAL: This telecommunication security program will benefit the medical and manufacturing community by protecting images with a very high bandwidth, such as medical images and manufacturing blueprints.

REFERENCES:
R&D for the NII: Technical Challenges, EDUCOM, 1994.

ARPA SB961-012TITLE: Nanostructural Materials

CATEGORY: 6.1 Basic Research; Materials, Processes and Structures

OBJECTIVE: Advance the technology and production/manufacturing of nanostructural materials and their fabrication into components, and accelerate the transition of unique materials from the laboratory into reliable, reproducible, economic, commercial-scale production.

DESCRIPTION: Materials having feature sizes (i.e., grain or particle sizes, layer thicknesses) in the nanometer-scale range (1 to 100nm) are currently being developed for a wide range of applications. Among such potential applications are catalytic supports and devices, sensors, filters, electronics, thermal and electromagnetic protection coatings, wear resistant coatings, electrical storage and generation systems, and optical and structural components. These materials offer unique physical properties (i.e., hardness/wear resistance, optical, dielectric, magnetic, mechanical, biocompatibility), transport properties (i.e., thermal, atomic diffusion), and improved processing characteristics (i.e., faster sintering kinetics, superplastic forming). Current fundamental research programs are investigating, for example, new materials, and new process/synthesis methods, such as molecular self-assembly, microstructure-property relationships, transport phenomena, and modeling of the kinetics and thermodynamics with respect to microstructure and processing. Examples of typical processing methods include vapor-phase synthesis (e.g., CVD, PVD, VLS synthesis), mechanical milling of solids, and solution chemistry (e.g., organic precursors). Technical challenges include process scale-up, fabrication of large parts without loss of the critical feature size, control of the distribution and morphology of phases in bulk quantities, and demonstration of performance in prototype components and systems. Proposed efforts may involve materials development, synthesis and processing methods development, component fabrication, and in-situ process monitoring and control.

PHASE I: Identify and develop a technological advancement in the manufacturing of nanostructural materials and their fabrication into components. Justify the basis for the proposed advancement via consideration of scientific, technical, manufacturability, and affordability issues. Demonstrate feasibility of the process and performance of the materials. Select a relevant military application for demonstration in Phase II.

PHASE II: Demonstrate the capabilities of the proposed technology via a specific material, class of materials, component, or class of components. Evaluate materials and component performance relative to a baseline. Specifically address manufacturability, reproducibility, technical feasibility, and affordability for process scale-up.

MILITARY NEED: Unique materials (e.g., high temperature alloys, composites, semi-conductors) have repeatedly provided the basis for critical military capabilities. Nanoscale materials offer unique electrical, optical, chemical, and mechanical properties of potential benefit in a range of defense applications. Military use requires commercial availability of new materials, and commercial development of new materials is a high-risk enterprise. Military application requires accelerating commercialization of such materials by reducing risk, and identifying applications in the scale-up and development phases.

COMMERCIAL POTENTIAL: Commercial promise is based on many unique properties that have been exhibited by some researchers on a laboratory scale. Extremely high strength single phase and multiple phase (composite) nanoscale materials should be of interest for lightweight mechanical structures, commercial tools, and coatings. Porous nanoscale structures offer promise as high surface area substrates for chemical catalysts, energy storage/generation devices, pollution abatement systems, and electrically selective ion-exchange membranes. Nanoscale grain size structural materials allow superplastic forming of complex-shaped products from otherwise refractory materials.

REFERENCES:
1) "Microcomposites and Nanophase Materials", Conference Proceedings, eds. D.C. Van Aken, G.S. Was, and A.K. Ghosh, TMS: Warrendale, PA, 1991
2) R.D. Schull, "Nanometer-Scale Materials and Technology," JOM, November 1993, pp.60-61
3) G.M. Chow, et.al., "Synthesizing Submicromeyer and Nanoscale Particles via Self-Assembled Molecular Membranes," JOM, November 1993, pp.62-65
4) A. Manthiram, et. al., "Nanophase Materials in Solid Freeform Fabrication," JOM, November 1993, pp.66-70.
5) P.V. Kamat, "Nanocrystalline Semiconductor Thin Films for Microelectronic and Optoelectronic Applications," Materials Technology, Vol. 9, 1994, pp.147-149.
6) S. Amelinckx, et. al., "A Structural Model and Growth Mechanism for Multishell Carbon Nanotubes," Science, Vol. 267, 3 March 1995, pp.1334-1338.
7) M. Nishizawa, et. al., "Metal Nanotubule Membranes with Electrochemically Switchable Ion-Transport Selectivity," Science, Vol. 268, 5 May 1995, pp.700-702.

8) W.A. deHeer, et.al., "Aligned Carbon Nanotube Films: Production and Optical and Electronics Properties," Science, 12 May 1995, Vol. 268, pp.845-847.

ARPA SB961-013TITLE: Advanced Systems to Enhance Patient Care at Remote Locations

CATEGORY: 6.2 Exploratory Development; Biomedical Technology

OBJECTIVE: Design and create teleoperator and telemanipulator devices that can provide medical and surgical therapy at remote sites, including the far forward battlefield.

DESCRIPTION: The opportunity exists to create teleoperator devices that can provide remote medical or surgical therapy. The challenges include: 1) solve the "latency" or "lag" problem for long distance teleoperation, 2) highly dexterous telemanipulators which are scalable, 3) tactile displays of high fidelity, 4) incorporation of microsensors into devices to create "smart" manipulators, and 5) design entire remotely-controlled micro-instruments (micro-robots). PHASE I: Perform the design and early breadboard for a remote manipulator, tactile display, or micro-manipulator.

PHASE II: Create a prototype telemanipulator, tactile display, or micro-robot capable of enabling a therapeutic or diagnostic maneuver at a remote site. There must be compatibility with current generation networks, and it must be intuitive to the operator.

COMMERCIAL POTENTIAL: The development of remote medical and surgical therapeutic devices will create a market for an entirely new set of diagnostic and therapeutic modalities for the delivery of health care. Current devices could be converted to a new generation of intelligent instruments, expanding the capabilities of existing diagnostic and therapeutic devices.

REFERENCES:
1) Green, P.S., J.W. Hill, J.F. Jensen, and A. Shah, "Telepresence Surgery," IEEE Engineering in Medicine in Biology, 14:324-29, 1995.
2) Sheridan, T.B., Telerobotics, Automation, and Human Supervisory Control, MIT Press: Cambridge, MA., (1992).

ARPA SB961-014TITLE: Development of Impurity Tolerant Electrocatalysts for Proton Exchange Membrane (PEM) Fuel Cells

CATEGORY: 6.2 Exploratory Development; Electronics, Environmental Quality, Surface/Under Surface Vehicles, Ground Vehicles

OBJECTIVE: Develop efficient, high-activity anode and cathode electrocatalysts for proton exchange membrane (PEM) fuel cells, which are tolerant to impurities in both the fuel and air streams.

DESCRIPTION: Performance improvements in PEM fuel cells have lead to numerous potential applications on the battlefield and in the civilian sector. Despite the use of noble metal catalysts, however, fuel impurities (e.g., sulfur and carbon monoxide which may be intrinsic in the fuel or are by-products of fuel processing) can reversibly poison the anode and decrease performance dramatically. "Scrubbing" the fuel is an expensive and time-consuming process that may limit the ultimate utility of fuel cells. Similarly, pollutants in the air (whether they be smoke, smog, or battlefield contaminants) may degrade cathode performance. Cathode performance may also be lowered in direct methanol oxidation PEM fuel cells by methanol permeating through the proton exchange membrane. Thus, the development of impurity-tolerant electrocatalysts is critical to the deployment of these high-efficiency, quiet, and environmentally sound power systems.

Catalyst development may follow the lead of the chemical processing industry where alloys and/or additives (such as alkali metals or rare earth oxides) are used to improve the impurity tolerance of catalysts. Alternatively, discrete transition metal cluster compounds may prove to be effective electrocatalysts due to their high selectivity toward only the fuel molecule. One can also envision the use of hybrid materials. Finally, there is the potential for both classes of catalysts to oxidize impurities directly, an effective tactic employed at elevated temperatures.

PHASE I: Tests of membrane electrode assemblies incorporating advanced anode and/or cathode electrocatalysts with fuels and/or air with impurity levels at "real world" levels.

PHASE II: Stack tests (>250 W) of optimized electrocatalysts (including >1000 hr life test) on "worst case" fuels and/or air.

COMMERCIAL POTENTIAL: The development of impurity tolerant electrocatalysts will lead to the manufacturing of fuel cells with a longer potential useful life. Balance-of-plant costs will also decrease since extensive fuel and/or air filters/scrubbers will not be required. Finally, the system will be able to operate on lower grade (and therefore lower cost) fuels.

REFERENCES:
Appleby and Foukes, *Fuel Cell Handbook,* (Krieger Publishing, 1993).

ARPA SB961-015 TITLE: Magnetic Oxide Films

CATEGORY: 6.1 Basic Research; Materials, Processes and Structures

OBJECTIVE: Prepare high quality films of magnetic oxide materials over large areas and at high yield on technologically useful substrates. These materials must be consistent with applications to magnetic field sensors, as well as other magnetic devices.

DESCRIPTION: Recent discoveries of large magnetoresistive effects in magnetic oxide films points up the need for developing the deposition methods and tools to prepare these films, as well as other technologically useful magnetic oxides, in a consistently high quality form over large areas and with high yield. It is essential that the properties that make these films useful be preserved. The deposition environment must therefore be monitored and controlled.

PHASE I: Demonstrate that the deposition method proposed can be used to prepare the magnetic oxide films with the desired properties.

PHASE II: Demonstrate the conditions necessary to prepare high-quality films over large areas with high yield. This would include the development of the appropriate monitoring, as well as control tools.

COMMERCIAL POTENTIAL: The successful development of these deposition methods will create markets not only for these useful films (which can be used in many sensor, high frequency and precision machining applications), but for the deposition, monitoring, and control methods that make the high quality deposition of these films possible.

REFERENCES:
S. Jin et al. Science 264, 413 (1994).

ARPA SB961-016 TITLE: Solid State Growth of Ceramic Single Crystals

CATEGORY: 6.2 Exploratory Development; Sensors, Electronics

OBJECTIVE: Develop a method for the solid state conversion of complex-shaped polycrystalline ceramics to single crystal products.

DESCRIPTION: Functional ceramics are essential to the operation and performance of many high technology products. Optical, magnetic, electronic, ferroelectric, piezoelectric, and elastic properties are tensor properties dependent on crystallographic orientation. While powder processing facilitates the low-cost formation of near-net shape components and cofired structures, such as multilayer substrates and capacitors, the random crystallographic texture obtained by this method may not optimize the performance relative to single crystals. However, manufacturing methods for single crystals are not generally applicable to the low-cost production of complex, near-net shape components. The use of oriented seed grains for secondary grain growth to accomplish the solid state conversion of polycrystalline near-net shape components to either single crystals or highly textured single crystals has the potential to fabricate single crystals at polycrystalline prices and to manufacture unique devices not otherwise manufacturable. Textured aluminum oxide fibers have been fabricated using seed grains of ferric oxide, which are aligned during fiber spinning. Textured cobalt rare earth magnets are fabricated by magnetically aligning large seed grains in the presintered powder compact, which consume the smaller non-aligned grains following densification.

Depending on crystal symmetry, the orientation of one to three crystallographic axes of the seed grains may be needed to self-assemble the random polycrystalline body into a single crystal. Strategies, such as transient solid phase sintering, must be developed to minimize pore entrapment during grain growth if a dense single crystal is required. The synthesis of faceted seed grains, which are alignable in shear flow fields, magnetic field gradients, or electric field gradients, may be useful to achieving the goals of this topic.

Innovative approaches are sought for the low-cost solid state conversion of polycrystalline components to single crystal form. The single crystal component and/or device must be application driven. Relaxor ferroelectric sonar transducers and holographic crystals for memory storage are of particular interest.

PHASE I: Develop low-cost, solid state processes for the conversion of polycrystalline ceramic components to single crystal form. The composition of the chosen material system must have a compelling application enabled by the single crystal or textured form. The processes developed should be scalable and translatable to new systems.

PHASE II: Using the process developed in Phase I, fabricate devices of interest and evaluate the device performance, manufacturing costs, and market potential.

COMMERCIAL POTENTIAL: Solid state methods for the growth of single crystal electroceramics offer the potential for affordable and scaleable manufacture of high value components. Growth markets include sensors, transducers, and electro-optics.

REFERENCES:
1) S.M.Sabol, G.L.Messing, and R.E.Tressler, "Textured Alumina Fibers with Elongated Grains," published in Volume I of HITEMP Review 1992 (NASA Conf. Publication 10104) page 21-1. [The 1992 NASA Hitemp Proceedings that contain this paper can be ordered through NASA Recon Office, tel (301) 621-0147. The relevant document # is CP-10401 (Volume 1); inquirers could also mention Ref.# 93X10315.]
2) W.H. Rhodes, "Controlled Transient Solid Second-Phase Sintering of Yttria," J. American. Ceramic Society, Vol 64
(No. 1), 1981, p. 13-19.
3) A.J.Moulson, J.M.Herbert, *Electroceramics: Materials, Properties, Applications*, Chapman & Hall, London, (1990).

ARPA SB961-017 TITLE: Quasi-Phasematched (QPM) Non-Linear Frequency Conversion

CATEGORY: 6.2 Exploratory Development; Electronic Warfare

OBJECTIVE: Develop a new class of quasi-phasematched (QPM) non-linear frequency conversion devices in the 2 to 5 µm mid-infrared spectral regions.

DESCRIPTION: Mid-infrared sources in the 2 to 5 µm region, based on QPM non-linear frequency conversion devices, will have broad applications in laser based infrared countermeasures, industrial process monitoring, and atmospheric and environmental monitoring. Recently, periodically-poled lithium niobate QPM non-linear frequency conversion devices have been demonstrated for frequency conversion in the mid-infrared spectral regions. The objective of this effort is to develop a new class of QPM non-linear frequency conversion devices in the 2 to 5 µm spectral region, based on ferroelectric crystals other than periodically-poled lithium niobate. For these devices to be practical, the issues related to fabrication, efficiency, tuning range, damage thresholds and device integration with pump sources must be further developed.

PHASE I: Demonstrate QPM non-linear frequency conversion in the 2 to 5 µm region based on ferroelectric crystals other than periodically-poled lithium niobate, using either diode laser or diode pumped solid state laser pump sources. Identify the critical issues and fabrication methods for high average power operation in both continuous wave and pulsed mode.

PHASE II: Based on the results of Phase I, demonstrate high average power mid-infrared sources in the 2 to 5 µm region and evaluate device performance.

COMMERCIAL POTENTIAL: The development of efficient, tunable, mid-infrared sources will have broad commercial applications in industrial process monitoring, and atmospheric and environmental monitoring.

REFERENCES:

L. E. Myers, G. D. Miller, M. L. Bortz, R. C. Eckhardt, M. M. Fejer and R. L. Byer, 1994 Non-Linear Optics Conference, Paper PD8 (IEEE LEOS, Piscataway, NJ, 1994).

ARPA SB961-018TITLE: Advanced Thermoelectric Materials for Cooling and Power Generation

CATEGORY: 6.2 Exploratory Development; Electronics; Environmental Quality; Materials, Processes and Structures

OBJECTIVE: Develop and demonstrate the application of advanced thermoelectric materials in either cooling or power generation applications of relevance to DoD.

DESCRIPTION: The development of thermoelectric materials with high ZT (>>1) may raise the efficiency of thermoelectric cooling devices to above that obtained with chlorofluorocarbon based compressors. This may lead to the production of all solid state, high reliability, low power, low vibration cryocoolers for advanced electronics and detectors, as well as refrigeration units with no pressure vessel, no moving parts, and no acoustic signature (e.g., for submarines). In addition, such materials may be used for thermoelectric power generation from either a fuel based heat source (e.g., furnace or solar radiation) or for exhaust heat recovery. Key to the success of these new devices is the identification, synthesis, and characterization of new materials (or classes of materials), new morphologies (e.g., quantum wells, aerogels, or nanostructured materials), and/or new device structures (e.g., thin films). The temperature range of interest will clearly depend on the ultimate application (e.g. cryocooling, air conditioning, or power generation). However, broadening the optimum temperature range of operation is also important.

PHASE I: Synthesis, characterization, and measurement of the thermal and electrical properties of advanced thermoelectric materials with high ZT (>>1).

PHASE II: Continue the optimization and characterization of these new materials and demonstrate their use in a thermoelectric device (e.g. for either cooling or power generation).

COMMERCIAL POTENTIAL: Despite the low efficiency of today's thermoelectric materials, applications include space power, cooled picnic baskets, and photodetectors. The market for these products, as well as for conventional refrigerators, air conditioners, and cooling devices for electronic circuits, will grow substantially as the ZT of new materials increases and the ban on chlorofluorocarbons approaches.

REFERENCES:

Thermoelectric Handbook, M. Rowe, ed. CRC Press, (1994).

ARPA SB961-019TITLE: High Fidelity Sensory Input for Modeling and Simulation of Battlefield Casualties

CATEGORY: 6.2 Exploratory Development; Biomedical Technology

OBJECTIVE: Create a new generation of sensory input devices (e.g., tactile, olfactory, etc.) that will increase the fidelity of simulating combat casualties in the battlefield environment. This includes simulating medical forces for planning and training in the virtual battlefield, as well as individual training on a virtual body with ballistic wounding.

DESCRIPTION: Create new and innovative devices that will increase the fidelity of virtual environments for combat casualty training by simulating senses other than visual and auditory. These devices must be compatible with either the Visible Human data set (available from the National Library of Medicine) and/or with the current generation of battlefield environment utilizing DIS/SIMNET networking. They must be small, portable, unobtrusive and intuitive.

PHASE I: Create the design and breadboard prototype for proof-of-concept.

PHASE II: Deliver an early prototype of the device, demonstratable upon either the Visible Human model or within the DIS/SIMNET environment.

COMMERCIAL POTENTIAL: Medical training is moving into simulators to replace animal models for training in combat casualties. Within the civilian sector, simulators are needed for surgical pre-planning, simulation and training of surgical procedures, image guided therapy, and outcomes prediction. This is an entirely new market, which can be expanded not only into the medical (physician, resident, or medical student) arena, but migrated down as educational tools for college and post-graduate training, as well as general heath care education for grade schools and high schools.

REFERENCES:
1) Satava, R.M., K. Morgan, et.al., Interactive Technology and the New Medical Paradigm for Health Care, IOS Press: Washington, D.C., 1995.
2) Ellis, S.R., "Nature and Origins of Virtual Environments: A Bibliographical Essay," Computing Systems in Engineering, 2:321-47, 1991.

ARPA SB961-020TITLE: Growth of New Single Crystal Substrates for Cuprate Superconductors

CATEGORY: 6.2 Exploratory Development; Materials, Processes and Structures

OBJECTIVE: Grow large (>4 inch diameter), very high quality, twin free, low dielectric loss, single crystals of compounds that can be used as substrates for the growth of microwave quality films of the cuprate superconductors.

DESCRIPTION: Until now, most high microwave quality films of yttrium barium copper oxide (YBCO) and other cuprate superconductors have been grown on lanthanum aluminate which has the detrimental quality of forming twins at a temperature below the growth temperature for the cuprates. Recently, compounds like strontium aluminum tantalate and doped lanthanum aluminate have been found to have the desired qualities, but large single crystals have not yet been demonstrated.

PHASE I: Demonstrate the growth of new improved substrate materials with the desired properties that will provide for the growth of microwave quality cuprate films.

PHASE II: Scale up the growth of high quality crystals to a size which is consistent with the needs of the superconducting device community (2-4 inch diameter).

COMMERCIAL POTENTIAL: The successful development of these substrates will not only create markets for these substrates, which can be substantial, but will significantly benefit the fledgling superconducting device community by significantly improving the reproducibility of its devices. The superconducting films can be used in many applications to wireless communications, radar and electronic warfare.

REFERENCES:
IEEE Transactions on Applied Superconductivity, 5, No. 2, 1995, pg. 3203.

ARPA SB961-021TITLE: On-Chip Microfluidics for Integrated BioAnalysis Systems

CATEGORY: 6.2 Exploratory Development; Chemical and Biological Defense

OBJECTIVE: Develop reliable on-chip microfluidic components for integrated analysis systems involving biological fluid flow.

DESCRIPTION: There are many potential advantages for applying Micro-Electro-Mechanical Systems (MEMS) technology to the challenge of achieving rapid, accurate, and affordable analysis of biological molecules, agents, and toxins. Using MEMS to store and manipulate biological fluids, however, represents a significant departure from non-biological MEMS because of the need for devices and structures to come into routine contact with aqueous solutions that may contain corrosive salts or materials that tend to absorb and aggregate on surfaces. Requirements of this topic are to develop novel MEMS-based structures, sensors, and actuators or to modify existing structures, sensors, and actuators, in order to achieve reliable and well-characterized on-chip flow of biological fluids. Proposers may submit concepts for systems that achieve integrated transport, detection, and identification of a specific bioagent or group of bioagents, using novel micro-fluidics techniques, or concepts for novel technologies, including, but not limited to, specific 3-D microfabrication or surface modification technologies, to allow the tailored modification of physical surfaces with which biological fluids are likely to come into contact in miniaturized fluidic structures.

PHASE I: Identify a technology or combination of technologies to achieve reliable and biocompatible on-chip storage and transport of biological fluids. Outline current maturity of the proposed technology. Identify and analyze the major problem areas associated with this technology. Produce a development plan which addresses the approach to solving key technology issues. Identify quantitative goals for system performance. Provide evidence that the scientific principles on which the proposed technology is based are sound, and justify further work. Develop a Phase II plan and schedule that identifies the work necessary to demonstrate technical feasibility and to increase the potential of the technology to transition to Defense and private-sector applications.

PHASE II: Develop and demonstrate Phase I systems/technologies. Explore critical parameters and optimize the design. Document work performed. Provide in-depth performance evaluation and an analysis of the potential for further integration and miniaturization of the technology.

COMMERCIAL POTENTIAL: This technology applies to medical diagnostics and environmental protection product markets.

REFERENCES:
1) Proceedings of the 1994 Solid-State Sensor and Actuator Workshop, Hilton Head Island, SC, June 13-16, 1994.
2) Stenger, D.A., and McKenna, T.M. (eds.), Enabling Technologies For Cultural Neural Networks, San Diego, CA: Academic Press: 1994.
3) Sze, S.M. (ed.), Semiconductor Sensors, New York, NY: John Wiley & Sons, Inc.,1994.

ARPA SB961-022Title: Electronic Systems Manufacturing (ESM)

CATEGORY: 6.2 Exploratory Development; Electronics, Manufacturing Science and Technology, Modeling and Simulation

OBJECTIVE: Develop manufacturing and associated technologies that enable on-demand, volume-independent, but scalable, high yield production of electronic systems, subsystems, and modules.

DESCRIPTION: Electronic systems and subsystems represent about 40% of the Defense acquisition budget and are the critical enabling technology that differentiates our weapon systems. As the DoD downsizes, it will become increasingly important to be able to leverage the merchant contract manufacturing infrastructure for economies of scale to reduce unit production costs. The objectives of the Electronic Systems Manufacturing (ESM) program are to put in place a capability that concurrently provides both quick reaction, rapid prototyping and cost-effective volume production when needed. Technologies necessary to achieve this goal include: 1) integrated 3-D CAD and analysis tools to support the error-free electrical/mechanical/thermal design of printed wiring assemblies and subsystems, 2) software systems to support paperless data exchange from design to the manufacturing floor, 3) simplified manufacturing processes to reduce costs, and 4) electronic brokering technologies to shorten lead times for discrete components and printed wiring boards. This effort is seeking innovative software tools, and flexible manufacturing equipment and processes to support the ESM objectives. Efforts may address any topical area that supports ESM objectives, however, the four areas identified above are of particular interest. Proposals should clearly identify the areas of greatest impact and quantify the anticipated results.

PHASE I: In detail, define and validate the approach to developing technologies for rapid prototyping and/or production techniques as applied to merchant, contract electronics manufacturing and assembly. For software tools, provide requirements definition and prototype critical functionality, as appropriate. For manufacturing equipment and processes, unambiguously quantify benefits of approach with preliminary experiments, prototypes, or simulations, as appropriate.

PHASE II: Implement the plans developed under Phase I. For software tools, complete core functionality with appropriate documentation, then validate operation and utility. For manufacturing equipment and processes, complete detailed experimental series and demonstrate new capabilities on prototype tool.

COMMERCIAL POTENTIAL: The world electronics system market is now about $700 billion and is forecasted to exceed $1 trillion by the end of the decade. Technologies that lead to improvements and cost-reductions in electronics manufacturing will have great commercial potential.

REFERENCES:
1) "Electronics Manufacturing Technology Roadmaps and Options for Government Action," prepared by the National Electronics Manufacturing Framework Committee (1994).
2) "The National Technology Roadmap for Electronic Interconnections," pub. by The Institute for Interconnecting and Packaging Electronic Circuits (IPC), (1995).
Additional and related information available on World Wide Web at:
http://eto.sysplan.com/ETO
http://esc.sysplan.com/ESC/

ARPA SB961-023TITLE: <u>Development of Low-Cost, Hand-Held Displays Utilizing Microelectromechanical Devices</u>

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Electronics

OBJECTIVE: Demonstrate novel display technology, based on microelectromechanical devices capable of rugged, low-power operation and high resolution, suitable for portable information tools.

DESCRIPTION: High image quality, low-power consumption displays are needed for lightweight, hand-held information terminals. The military has specific requirements for wide operational temperature range, ruggedness, and high contrast in full sunlight ambient. Several new concepts are being developed which utilize microelectromechanical (MEM) devices as shutters, light guides, or reflective surfaces to provide high resolution display imagery. Previous concepts have developed large screen projection displays based on micromirror devices, however, these devices have limited utility for hand-held applications. This topic is seeking to explore new concepts and develop prototype demonstrations using integrated electronic and MEM devices for displays suited to low power, portable, hand-held displays such as found in today's personal digital assistants.

PHASE I: This phase is intended to be a design characterization of new display architectures and must address fabrication plans and costs, resolution, color capability and greyscale, as well as system power requirements. Preliminary experimental characterization of concepts during Phase I is desirable.

PHASE II: This phase will involve the fabrication and characterization of an operational test device to demonstrate the suitability of this display architecture for use in a portable, rugged, hand-held display device.

COMMERCIAL POTENTIAL: The development of such a display technology will be well-suited to a variety of military and commercial needs. For commercial applications, low-power, high resolution displays are needed in applications, such as personal digital assistants, and today's conventional solutions leave much to be desired in terms of resolution and color/grey-scale capability.

REFERENCES:
Society for Information Display International Symposium, Digest of Technical Papers, Jay Morreale, Editor, Vol. XXVI (1995).
Additional and related information available on World Wide Web at:
http://eto.sysplan.com/ETO/ (see High Definition Systems and MEMS Programs)

ARPA SB961-024TITLE: Wide-Temperature Liquid Crystal Materials and Cells for Reflective Displays

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Electronics

OBJECTIVE: Demonstrate reflective liquid crystal device technology with clear potential for obtaining all of the following simultaneously: -30° C to +50° C operating range, 20:1 contrast in outdoor ambient, video-rate response, full color, 40% white diffuse reflectivity and passive matrix addressable to million pixel counts.

DESCRIPTION: High image quality, low power consumption flat panel displays are needed for lightweight, hand-held information terminals. The military has a specific need for displays which have low power consumption, high contrast in a full sunlight ambient, and which operate satisfactorily over a wide temperature range. Reflective liquid crystal displays are attractive because they generally have low power consumption. Current reflective liquid crystal displays have shortcomings in one or more of the following: operational temperature range, contrast, response time, reflectivity, ability to display full color, bistability and switching voltage (which translates to high-cost).

PHASE I: Identify promising liquid crystal materials and/or cell structures which offer significant advantages over currently known reflective liquid crystal display types, such as twisted nematic and super-twisted-nematic, stabilized cholesteric, polymer dispersed, and surface stabilized ferroelectric. Fabricate single pixel cells and demonstrate the potential advantages of the new concept(s) by measuring relevant characteristics such as the following: reflectivity and response time vs. voltage, temperature effects on contrast and response time, contrast under controlled lighting conditions, specular and diffuse reflectivity, and capacitance and bistable behavior (if applicable).

PHASE II: Demonstrate and deliver a prototype monochrome reflective display (e.g., 7.5 cm x 10 cm, 320 column x 240 row) based on the Phase I concept which demonstrates wide temperature range, and high-contrast in outdoor ambient and video-rate response. Determine potential for obtaining color using this technology.

COMMERCIAL POTENTIAL: High contrast, wide temperature, reflective liquid crystal displays are in demand for a broad range of outdoor-use products, including laptop computers, pagers, personal digital assistants, and portable telephones.

REFERENCES:
Society for Information Display International Symposium, Digest of Technical Papers, Jay Morreale, Editor, Vol. XXVI (1995)
Additional and related information available on World Wide Web at:
http://eto.sysplan.com/ETO/ (See High Definition Systems)

ARPA SB961-025TITLE: Efficient Inorganic Light Emitting Device Technology for Portable Emissive Displays

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Electronics

OBJECTIVE: Demonstrate a power-efficient and reliable inorganic electroluminescent display technology compatible with plastic substrates.

DESCRIPTION: High image quality, low-power consumption flat panel displays are needed for lightweight, hand-held information terminals. The military has a specific need for displays which have low-power consumption and are reliable, very thin, rugged, and lightweight. Conventional thin film alternating-current electroluminescent displays are power inefficient, use relatively bulky power supply electronics, high-cost, high-voltage driver chips, and cannot be fabricated using unbreakable plastic substrates. Organic direct-current electroluminescent displays use lower drive voltages and can be made using plastic substrates, but are not sufficiently reliable for demanding applications.

PHASE I: Demonstrate low voltage inorganic electroluminescent device concept that is compatible with plastic substrates and that promises good reliability and power efficiency (greater than 1 lumen/watt). Assess potential for obtaining greater than 1 lumen per watt, red/green/blue color and competitive manufacturing cost.

PHASE II: Demonstrate and characterize a multi-pixel, monochrome, electroluminescent display which uses a plastic substrate and evaluate suitability for hand-held display system applications.

COMMERCIAL POTENTIAL: Power-efficient, lightweight, emissive flat panel displays would be useful for a broad range of electronics products, including laptop computers, pagers, personal digital assistants, and portable telephones.

REFERENCES:
Society for Information Display International Symposium, Digest of Technical Papers, Jay Morreale, Editor, Vol. XXVI (1995).
Additional and related information available on World Wide Web at:
http://eto.sysplan.com/ETO/ (See High Definition Systems)

ARPA SB961-026TITLE: Energy Scavenging for Small Data Collection Systems

CATEGORY: 6.2 Exploratory Development; Surface/Undersurface Vehicles

OBJECTIVE: Develop and demonstrate small power supply systems that scavenge energy from the environment to power long-endurance data collection devices.

DESCRIPTION: Small power supply systems that scavenge energy from the environment are needed for various types of long-endurance data collection devices. This type of power supply would be used for data collection systems which require a combination of endurance and small package size not achievable using batteries alone, or for systems in locations that make battery replacement difficult or impractical. For the applications envisioned, the size of the power system require ranges from integrated circuit size to approximately one cubic foot. Applications for this type of power supply include systems that operate on land, underwater, or on the water surface. Land systems may be stationary or attached to a moving vehicle. Maritime systems may be free floating, resting on the bottom, moored, or attached to a moving vessel. Energy sources could include wind, ambient light, temperature differences and changes, vibration, accelerations, sound, ambient RF fields, pressure changes, water waves, and water flow. It is expected that power scavenging systems will require an energy storage unit to provide higher power on an intermittent basis for communications, or for energy, when the environmental source is unavailable. In addition, a low-power control system may be required to regulate power to the data collection system, and control power to and from the storage unit. Primary interest is in novel energy scavenging systems, as opposed to packaging of conventional devices, such as solar cells.

A militarily significant data collection task should be selected to demonstrate energy scavenging. Energy scavenging should make it possible to increase the endurance or decrease the size of the data collection system for the task selected. Example tasks include tagging of vehicles, cargo and weapons; land and maritime surveillance; and the collection of meteorological or oceanographic data. Although data retrieval could be accomplished by recovering the device and accessing stored information, a data collection system that can communicate collected data is necessary for some tasks and preferred for most tasks.

PHASE I: For the selected task(s), assess the power requirements, and develop and demonstrate novel energy scavenging devices. Determine, through measurement and modeling, the power available under various conditions.

PHASE II: Using the results of Phase I, design and build a complete energy scavenging and storage system for the selected task(s). The performance of the complete system should be demonstrated and evaluated in selected environments.

COMMERCIAL POTENTIAL: The development of energy scavenging systems will have broad commercial applications, including the development of long endurance, data collection systems that require no maintenance. Applications include the detection of chemical effluents, tracking of cargo, shipboard hazard sensing, security alarm systems, collection of scientific data, and distributed meteorological sensing for more accurate weather prediction.

REFERENCES:
Smith, Norman F., "Energy Isn't Easy," Coward-McCann, Inc. , 1984

ARPA SB961-027TITLE: Magneto-Rheological (MR) Fluids, Devices, and Applications

CATEGORY: 6.2 Exploratory Development; Materials, Processes and Structures

OBJECTIVE: Develop new Magneto-Rheological (MR) fluids with enhanced performance; develop design concepts for hydraulic system components, actuators, valves, and dampers that take advantage of MR properties to reduce size and weight while extending performance beyond the limits of passive fluids; and develop manufacturing techniques to reduce the cost of MR fluids.

DESCRIPTION: MR fluids are liquids containing a suspension of ferric particles whose effective viscosity can be changed by the application of a magnetic field. These fluids have the potential to revolutionize the design of hydraulic systems, actuators, valves, active shock and vibration dampers, and other components used in military mechanical systems. At present, MR fluids are not readily available in production volumes or quality. The fluids that are available are expensive and suffer from problems with settling out of the suspended particles, and limited shear stress vs. magnetic field strength performance. Because of the relative scarcity of suitable fluids, little work has been done in development of devices that exploit the "smart materials" property of MR fluids. Efforts of interest include development of new fluids, development of application devices, and development of manufacturing processes that will reduce the cost of MR fluids.

PHASE I: Produce laboratory quantities of new fluids and measure their engineering properties; or design, fabricate, and test prototype devices that exploit MR fluid active properties; or design and implement laboratory scale processes for MR fluid manufacture.

PHASE II: Design and implement pilot scale processes for MR fluid manufacture, and produce system level quantities of new fluids; or design, fabricate, and test prototype systems that exploit MR fluidic devices.

COMMERCIAL POTENTIAL: MR fluids and devices have the potential to revolutionize the design of hydraulic systems, actuators, valves, active shock and vibration dampers and other components used in commercial mechanical systems, such as vehicle suspensions, machine tools, aircraft vibration isolation, etc. They have the potential for a dramatic improvement in the performance of such systems at reduced cost, and offer secondary gains through the reduced weight of hydraulic systems and structural actuators in commercial aviation and aerospace applications.

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8) E. Lemaire, G. Bossis, and Y. Grasselli, "Yield Stress and Structuration in Magnetorheological Suspensions," J. Magn. Magn. Mat. 122, p. 51 (1993).
9) Z. P. Shulman, V. I. Kordonsky, E. A. Zaltsgendler, I. V. Prokhorov, B. M. Khusid and S. A. Demchuk, "Structure, Physical Properties and Dynamics of Magnetorheological Suspensions," J. Magn. Magn. Mat. 12, p. 935 (1986g).
10) M. Whittle and W. A. Bullough, "The Structure of Smart Fluids," Nature 358, p. 373 (1992).

ARPA SB961-028 TITLE: Optical Network Switching Technology

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Electronics (Optoelectronics)

OBJECTIVE: Develop and demonstrate optical network switching technology that permits the routing of optical signals in a way that does not require the conversion of the signal from optical to electrical format.

DESCRIPTION: Research and develop optical network switching technology that permits the routing of optical signals in a way that does not require the conversion of the signal from optical to electrical format. Signal-header conversion and electronic control of the switching fabric is envisioned as the means for setting the switch, and methods of achieving high speed switching are of greatest interest. Applications include optical cross-bar, wavelength selective and very short pulse switching. Candidate optical switching technologies include electrically-controlled refractive index changes in thin film or fiber waveguides formed with electro-optically active materials, semiconductor amplifier switches, liquid crystal shutters combined with spatial or wavelength selective elements, and acousto-optically tuned filters. Performance goals should be targeted to meet the requirements for emerging optical networks operating at 2.5 Gb/s or higher, and to accommodate both digital and analog signal formats. Monolithic and hybrid integrated approaches leading to compact modules, designed to provide good cross-talk suppression, will be considered.

PHASE I: Develop a proof-of-concept switch design, either through fabrication of critical switching component prototypes, or by detailed modeling of switch design based on the demonstrated performance of existing components.

PHASE II: Develop and demonstrate a fully functional switch module capable of demonstrating critical functionality, and provide design documentation for full-scale switch development.

COMMERCIAL POTENTIAL: The development of efficient optical switching technologies will expand the commercial markets for data communication systems by enabling the application of broadband optical communication techniques to small (LAN, WAN) private networks. Compatibility with multiple signal formats will greatly enhance the capability to efficiently network diverse sources of information and stimulate the development of information superhighway applications while also accelerating the introduction of state-of-the-art facilities designed to meet DoD communication needs.

REFERENCES:
1) Technical Digest-Photonics in Switching Meeting; 1995 Technical Digest Series Volume 12, Optical Society of America,(1995).
2) Photonics in Switching Vol I & II, J. E. Midwinter ed., Academic Press Inc., (1993).

ARPA SB961-029TITLE: Materials and Process Technologies for Low-Power Semiconductor Circuits

CATEGORY: 6.2 Exploratory Development; Electronics; Materials, Processes and Structures; Manufacturing Science and Technology

OBJECTIVE: Develop viable alternate semiconductor substrate materials, tools, processes, and associated integration technologies that enable leading-edge, low-power, microelectronic device and circuit fabrication.

DESCRIPTION: Advances in integrated circuit (IC) manufacturing and innovations in design technologies are leading to new generations of wireless, portable information technology products and components. The capabilities of these new electronic systems include completely integrated functionality, embedded signal processing, high-speed data-processing, and high bandwidth communication channels. However, the cost-effective limitations of practical battery sources and thermal mitigation approaches are being reached since the high computational capabilities and data throughput of leading-edge ICs have also led to a marked increase in the electrical power dissipation. System size and weight, along with functionality and cost, are among the factors that differentiate these microelectronics systems. Additionally, in some cases, the spatial volume occupied by the microelectronics and associated support systems (i.e., power supplies, thermal mitigation, racks, etc.) is of a critical concern. Substantial reductions in the power dissipated by electronics will allow electronic systems to potentially utilize smaller volume batteries with longer useful lifetimes, reduce packaging costs, eliminate heat sinks and other thermal mitigation systems, and enable reductions in the capacities and quantities of external power supplies. Approaches that allow power supply reductions to the range of 0.9-1.2V are of particular interest. However, simply reducing the power supply voltage may also reduce the device operation speed, affecting performance. The objectives of this effort are to develop leading-edge semiconductor technologies that enable a significant reduction in power dissipation as compared to conventional technologies or approaches with minimal penalty to performance or functionality. Among the possible technology areas of interest are: ultra-shallow junction formation, thin-film silicon-on-insulator (SOI) substrate technologies, first-principles simulation models to couple alternate material and process manufacturing parameters to device and circuit metrics, and new approaches to process integration that incorporate low-power unit processes.

PHASE I: Provide a detailed technical approach that fully describes the specific technology approach and the anticipated benefits. Fully quantify the expected costs and impact on wafer flow. As appropriate, perform computer simulations, initial experiments, or provide detailed design of experiments to verify technology approach. As appropriate, provide plans on transitioning equipment/process technology to widest use in industry.

PHASE II: Implement the plans developed in Phase I to develop materials tools, processes, or other approaches. Complete experiments to validate equipment and process approach. For materials, demonstrate capabilities to produce sufficient quantities of high quality substrates.

COMMERCIAL POTENTIAL: Low-power electronics is an area of great interest to commercial semiconductor and system OEMs. Materials, processes, tools, or other approaches that allow reduced electronic power dissipation, without impacting performance, have tremendous application to merchant fabrication lines and will be incorporated rapidly in their operation.

REFERENCES:
1) "The National Technology Roadmap for Semiconductors," published by the Semiconductor Industry Association (1994).
2) "Silicon-on-Insulator Technology: Materials to VLSI," J.P. Collinge, Kluwer Academic Publishers, Hingham, MA, USA, (1991).
3) Also see recent proceedings from conference or symposia, such as:
IEEE Low Power Symposium
IEEE International SOI Conference
Proceedings of the ElectroChemical Society Meetings, Silicon Wafer Bonding: Technology and Applications, most recently held in May 1995 in Reno, NV.

ARPA SB961-030TITLE: Maskless Lithography for Microelectronic Devices with Features of 0.1 Microns

CATEGORY: 6.2 Exploratory Development; Electronics

OBJECTIVE: Demonstrate subsystems for a tool enabling, cost-effective fabrication of microcircuits with 0.1 micron design rules.

DESCRIPTION: The fabrication of future advanced semiconductor devices will require the patterning of small features (0.10 microns and below) on the semiconductor wafer. Maskless writing of these features has long been a goal, but the application has been limited by slow writing times. A variety of approaches can potentially solve the throughput issue while meeting the requirements for pattern placement and dimensional control. These include recent advances in electron sources and optics, data path electronics, and stage control, which can be combined to provide a suitable combination of number of beams, current levels and uniformity, switching speeds, and reliability. New approaches that will address these key issues are being sought. In addition, alternative lithography technology approaches that can meet the goals of maskless 0.1 micron feature resolution with sufficient overlay, depth of focus, and wafer throughput, will also be considered. All approaches will be evaluated for effectiveness when implemented into future wafer writers. A path to eventual implementation through a commercial product must be outlined.

PHASE I: Fully define the approach, outline the detailed design, and begin initial experimentation that will provide the required improvement.

PHASE II: Develop and build a breadboard unit to demonstrate successful achievement of the goals. Provide a detailed plan for implementation into tooling commercially available to the industry.

COMMERCIAL POTENTIAL: The development of maskless lithography would be of significant value to the commercial integrated circuits industry, which has world sales of about $100B in 1995. This tool would be particularly useful for circuits with low manufacturing volume, eliminating the need for the expensive mask tooling which is unique with each circuit design. Furthermore, during the development phase for circuits with high volume applications, it would reduce the time to market and eliminate the mask tooling cost necessitated by design changes during development.

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2) "Applications of a High Throughput Electron Beam System for 0.3 micron Large Scale Integration," F. Mizuno et al, J. Vac. Sci. Tech. B12, 3440 (Nov/Dec 1994).
3) "Fast Electron Beam Lithography System with 1024 Beams Individually Controlled by a Blanking Aperture," S. Arai et al, J. Jap. Appl. Phys., 32, 6012 (1993).
4) "Negative Electron Affinity Cathodes as High Performance Electron Sources," A. W. Baum, K. Costello, V. Aebi, W.E. Spicer, R.F.W. Pease, SPIE Symposium, July 1995, San Diego, CA,papers 2522A-18 and 2550-7.
5) "High Speed Electron Beam Testing Using GaAs Negative Electron Affinity Photocathodes," C.A. Sanford, N.C. MacDonald, Microelectronics Engineering, 12, 213-220 (May 1990).

ARPA SB961-031TITLE: Virtual Prototyping Tools for Semiconductor Fabrication Equipment

CATEGORY: 6.2 Exploratory Development; Electronics; Materials, Processes and Structures; Manufacturing Science and Technology

OBJECTIVE: Develop a new class of integrated design tools to improve the design and implementation of advanced semiconductor manufacturing processes. These tools will enable physics-based modeling and simulation of semiconductor manufacturing equipment to predictively determine such characteristics as process response surfaces, process performance, particulate generation, and process space stability and controllability, prior to physical prototyping of the tool.

DESCRIPTION: The development of advanced semiconductor manufacturing tools, such as chemical vapor deposition (CVD) reactors, rapid thermal processors, etch systems, and lithography exposure tools are complex, multi-disciplinary tasks. While some computer aided design (CAD) tools have been employed to design mechanical components in these systems, the full potential for utilizing computer modeling and simulation tools to simplify and improve the equipment development process has yet to be fully exploited. Computer simulation tools, which account for first principle process reactions, are needed to model particle transport, plasma dynamics, heat transfer in the processing chamber, turbulence and chemical interactions in the gas flow and on the surface of the wafer, mechanical reliability of the wafer handling system, and the behavior of the control system. These software tools and models could be used to predictively develop unit processes and simplify tool integration. The same compact models used to design the tools might also be employed during tool operation to enable "intelligent" semiconductor processing, where the tool control system can itself determine and control the proper process variables to achieve a desired process characteristic (e.g., 3nm gate oxide). Although, some of these tools exist in the university community, few are available commercially or are widely used in the semiconductor manufacturing equipment industry. Furthermore, integration between different tools and links to technology-CAD frameworks and tools may be necessary to support systems level simulation and provide mappings between physical processes (i.e., particle transport) and material growth, and etch rates and profiles at appropriate spatial and temporal scales. Widespread use of such tools and tool frameworks would greatly reduce the development and lifecycle cost of new manufacturing tools by allowing the tool's designers to rapidly try out a number of alternative configurations without having to physically prototype the systems. The focus of this effort is to develop the core functionality of the software tools that enable virtual prototyping of semiconductor equipment.

PHASE I: Define a detailed specification of the proposed tool or environment that supports modeling and simulation of a class of semiconductor manufacturing tools. In detail, describe new or novel ideas or algorithms that will provide new modeling and simulation capabilities as they relate to equipment design. Develop a plan to validate the functionality and utility of the tool in the design or improvement of a semiconductor manufacturing tool.

PHASE II: Implement the tool or prototype environment defined in Phase I and demonstrate its utility in the development of some piece of semiconductor manufacturing equipment. Demonstrate core functionality of the software tools in relevant design problems.

COMMERCIAL POTENTIAL: The software tools and methods developed under this effort will have direct application to commercially available semiconductor manufacturing tools. The goals of this SBIR are to develop and industrialize software tools and design methodologies that enable equipment companies to better design, develop, and maintain high quality manufacturing tools by providing them with access to powerful, sophisticated modeling techniques. The codes themselves will allow equipment developers to accelerate development cycles and reduce costs through elimination of some physical prototyping. There is both primary and secondary commercial potential in the results of this effort, first from the software tools and licenses themselves, then from the improved design approach and novel equipment that results from using the developed codes and techniques.

REFERENCES:

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ARPA SB961-032TITLE: Low-Noise Optical Amplifier

CATEGORY: 6.2 Exploratory Development; Electronics; Command, Control and Communications

OBJECTIVE: Develop a low-noise, high-gain integrated optical amplifier for analog radio frequency (RF) photonic systems.

DESCRIPTION: Current optical amplifiers have been designed for digital optoelectronic systems, where noise is not a major consideration, or for digital optical networks, where size is not a major consideration. Analog RF photonic systems require ultra low-noise operation. Compact size is important to maintain small system size. Military systems influenced include antenna systems, RF receivers, satellite communications, and electronic warfare (EW) systems. Optical wavelength of 1.3 microns is of interest. Optical gains of at least 10 dB optical are of interest. Designs must be power efficient, i.e., maximize electrical power to optical gain. Noise comparable to high-power, low relative intensity noise (RIN) optical sources are of interest, i.e., noise power spectral densities of less than minus 165 dB per Hertz. Low distortion operation is of paramount importance.

PHASE I: Analyze and tradeoff low-noise, high-gain amplifier designs with possible limited breadboarding.

PHASE II: Fabricate a low-noise, high-gain amplifier, evaluate performance experimentally, and integrate the amplifier into a compact package.

COMMERCIAL POTENTIAL: The development of a low-noise, efficient, optical amplifier will have direct benefit to commercial RF photonics systems by enabling high performance operation. Satellite receiver systems for distribution of RF signals over large distances, with improved signal quality, will be made possible. Cellular radio systems will benefit by antenna remoting of the cells by high signal quality, low-loss RF photonics, without the need for complicated and expensive digital processing equipment. Local Area Networks for low distortion distribution of RF signals in large building complexes, aircraft and television network systems will be made possible.

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1) N. Anders Olsson, "Semiconductor Optical Amplifiers," Proceedings of the IEEE, vol. 80, number 3; 375(1992).
2) E. Desurvire, J.L. Zyskind, and C. Randy Giles, "Design Optimization for Efficient Erbium-Doped Fiber Amplifiers," Journal of Lightwave Technology, vol. 8, number 11; 1730(1990).

ARPA SB961-033TITLE: Development of Techniques to Ruggedize Graded Index Communication Grade Plastic Optical Fiber

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Computing and Software; Electronics

OBJECTIVE: Develop and demonstrate technology to ruggedize graded index communication grade plastic optical fibers, or develop and demonstrate rapid optical coating technology which will protect the plastic optical fiber from temperatures of -40 degrees C to +150 degrees C and moisture ingress, and which are tolerant to low earth orbit radiation.

DESCRIPTION: Recent developments in graded index plastic optical fiber have enhanced the bandwidth of the fiber by a factor of 100 over conventional step index fiber. This new development promises to have a major impact on future interconnect dominated military platforms, as well as commercial data communication and fiber to the home. However, for the full potential of this technology to be realized, an environmentally more rugged fiber needs to be developed. This program is focused on the development of more rugged plastic optical fiber by either the development of protective coating or the development of higher glass transition temperature core/cladding plastic fiber.

PHASE I: Research and develop ruggedized graded index plastic optical fiber (with losses of <300dB/km and bandwidth >2GHz/km) which will withstand temperature ranges of -40 degrees C to +150 degrees C, humidity, and radiation (long term low earth orbit). Preliminary experimental concept demonstration of the capability of either the plastic fiber, or of the coating technology to withstand these environmental constraints.

PHASE II: Extension of the techniques developed in Phase I to develop and demonstrate a viable: a) core/cladding technology, or b) rapid protective coating technology, for the graded index communication grade plastic optical fiber in order to produce the ruggedized plastic optical fiber in limited prototype production. It is important to demonstrate the potential of the approach to scale-up to full-scale production.

COMMERCIAL POTENTIAL: Ruggedized plastic optical fiber would have major commercial significance in computer data communication, local area networks, fiber to the home (the last mile), commercial avionics, as well as lowering the weight and providing Electro-Magnetic Interference (EMI) immunity in future automobile wire harnesses applications. Plastic optical fiber has started being explored for these commercial applications, but the exploitation of the technology has been limited, as the plastic optical fiber is not sufficiently rugged. Overcoming the current environmental limitations of plastic optical fiber would have dramatic impact on many future interconnect dominated, short distance commercial applications as well as military platforms.

REFERENCES:
Society of Photo-Optical Instruments Engineering, Special Issue on Plastic Optical Fiber, (1993).

ARPA SB961-034TITLE: Miniature Environmental Air Sampler for Biological Materials into Fluid

CATEGORY: 6.1 Basic Research; Chemical and Biological Defense, Sensors

OBJECTIVE: Preliminary design and construction of an efficient and effective air sampling device into a fluid phase that will function in an unattended miniature biological detector system. The efforts may address any new engineering designs.

DESCRIPTION: Biological detectors have the capability of detecting small numbers of bacteria/viruses and toxin molecules. However, the introduction of the sample is currently performed manually. This effort requires the solution of a major engineering problem: the automation of sampling air containing bacteria/virus and toxins into a fluid phase for a miniaturized detection system. This sampling module is a critical component in the development of unattended miniature biological sensors. The efforts may address any new miniature engineering designs that will enable efficient sampling of small amounts of air ranging from 1-2 ml of air or 5-10 ml of air, in as short a time period as possible, creating the smallest sampling systems, consuming the lowest possible power.

PHASE I: An engineering analysis feasibility and design study which will present several design possibilities for miniaturized air to fluid samplers that could be down-selected, constructed, and tested as prototype(s) in Phase II.

PHASE II: Detailed design and construction of an efficient and effective miniature air to fluid sampling module that will function in a miniature biological detector system.

COMMERCIAL POTENTIAL: The development of miniature air-fluid sampling systems will expand the commercial markets for environmental monitors for sick buildings, for medical infectious disease environments, and for agricultural storage facilities.

REFERENCES:
Journal of Aerosol Science, Vol 25, No 8 (1994).

ARPA SB961-035TITLE: Detection and Characterization of Underground Facilities (UGF)

CATEGORY: 6.2 Exploratory Development; Chemical and Biological Defense, Computing and Software, Environmental Quality, Modeling and Simulation

OBJECTIVE: Develop and integrate innovative algorithms and systems for detecting and characterizing the existence, operation, and prosecution of underground facilities (UGF) based on signal processing and fusion of data collected from local or remote geophysical and environmental sensors.

DESCRIPTION: The problem is to provide rapid and accurate assessments, including the location of sensors, imaging of the geophysical and environmental conditions in the vicinity of the UGF, imaging of the UGF structure, characterization of activity therein, battle damage assessment (e.g., locating and characterizing weapons detonated against UGFs, and of post-attack UGF activity), and collateral damage due to the release of hazardous materials (e.g., biological, chemical and nuclear materials) during and after attack. To address these problems, efforts will explore phenomenology, automated signal processing, automated physics-driven data fusion, visualization, physical modeling and simulation, process modeling, and decision analysis. Input data will come from diverse sensor types, including acoustic, seismic, electromagnetic, optical, chemical, biological and nuclear, meteorological, positioning, etc. The output assessments will be multi-tiered, providing the actionable information necessary for analyst- to commander-level users.

PHASE I: Design the algorithms or systems, and develop a model or proof-of-concept prototype of key elements of the proposed design to demonstrate the anticipated advantages of the proposed approach for providing rapid and accurate assessments of relevant data to one or more of the problems described above.

PHASE II: Develop, demonstrate, and document a full prototype that applies the approach.

COMMERCIAL POTENTIAL: This kind of geophysical and environmental analyses, and fusion of multiple types of sensors has application in petrochemical and mineral exploration, environmental and meteorological monitoring, and security surveillance.

REFERENCES:

"Tactical Multi-Sensor Fusion for Detection and Characterization of Underground Facilities," viewgraphs, May 1995. A copy of these viewgraphs may be obtained by calling (703) 696-2448.

ARPA SB961-036 TITLE: Small Chemical and Biological Agent Sensors

CATEGORY: 6.2 Exploratory Development; Chemical and Biological Defense, Sensors

OBJECTIVE: Develop advanced, spectral-based techniques for the rapid detection and identification of target materials (vapors and aerosols), including chemical and biological agents on the battlefield, that can be used in airborne and ground missions.

DESCRIPTION: A number of advanced technologies are emerging which show potential for mitigating the proliferation of chemical and biological weapons. They promise to resolve previously encountered technology problems. These novel technologies include:

- •compact, ultrasensitive, electro-optical techniques, such as 3-D laser doppler velocimeter, heterodyne detection, pseudo-random-noise pulse coding, three-dimensional spatial resolution array detector, etc. for rapid detection and identification of target materials, and providing downwind hazard prediction data.
- •miniature, hyphenated systems based on ion mobility spectrometry (IMS), mass spectrometry (MS) and gas chromatography (GC) (e.g., GC-IMS, IMS-MS, MS-MS, etc.), which rapidly detect and identify target materials.
- •optimal detection and estimation of dynamic spectral signatures from current and advanced sensors, such as those described above.

These technologies have the potential to produce low-cost, high-performance, fully automated payloads compatible with unmanned air vehicles, unattended ground sensor and other mission requirements. Applications include chemical-biological detection on the battlefield, battle space surveillance, and covert collection.

PHASE I: Define the technique, its application, and the approach to miniaturization and/or detection and identification algorithm optimization. Determine limits to miniaturization, sensitivity, and specificity through simulation.

PHASE II: Design and construct a breadboard model of the proposed technique, and determine its performance through laboratory test and evaluation. Prepare and deliver documentation of the design and evaluation results.

COMMERCIAL POTENTIAL: Pollution monitoring, terrorist attack mitigation, medical, agricultural, geological, recycling and manufacturing applications of these technologies are envisioned.

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2) Charles W. Therrien, " Discrete Random Signals and Statistical Signal Processing," Prentice Hall, 1992.

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10) J. F. Holmes and B.J. Rask, "Coherent, CW, Pseudo Random Code Modulated Lidar for Path Resolved Optical Remote Sensing," presented at the SPIE Conference on Atmospheric Propagation and Remote Sensing III, Orlando, Florida, April 1994.

ARPA SB961-037TITLE: Video Retrieval Based on Language and Image Analysis

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications

OBJECTIVE: Develop practical systems for automatic understanding and indexing of video sequences using both audio and video tracks.

DESCRIPTION: Automatic indexing of video is of increasing military and commercial interest. Military analysts must extract pertinent information from foreign television broadcasts, and must have the ability to rapidly locate segments from vast stores of video data. The design and construction of a system to extract content information from video sources, such as news broadcasts, video presentations, and video teleconferences, is desired. The information gleaned should be sufficient to support automatic indexing for later retrieval and/or automatic abstraction of video content.

Current approaches depend primarily on natural language understanding, which often fails to sufficiently categorize the associated imagery. What is needed is a system that can utilize both the audio and video to obtain retrieval terms that characterize the situation shown in the video. The audio and image analysis should work hand-in-hand to disambiguate terms, with imagery identifying speakers or objects, and language analysis providing keys to needed image analysis.

PHASE I: In detail, define an application, its data source, the desired output, an implementation framework, and the set of speech recognition and image understanding technologies that must be employed to achieve the result.

PHASE II: Develop a prototype video indexing system using the design from Phase I. The implementation should use COTS hardware and software as much as possible. Demonstrate the prototype on an existing archive of at least 12 hours of video.

COMMERCIAL POTENTIAL: The development of automatic video indexing systems will enable routine access to the vast quantity of video that is being captured digitally on a daily basis. Potential users of such systems include scholars doing academic research, journalists searching for background, TV producers editing video clips, legal assistants reviewing previous testimony, military analysts compiling databases on regions or topics of interest, etc. Further advancement of this technology could lead to applications beyond retrieval, such as advanced human-computer interfaces, in which the automated system reacts to the user based on both what it sees and hears.

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2) Proceedings of the Video Photogrammetry and Exploitation Conference, Washington DC,

May 1995.
3) Journal of Multimedia Tools and Applications, Vol. 1 No. 1, March 1995.

ARPA SB961-038 TITLE: Lightweight, Low-Cost Surveillance Arrays

CATEGORY: 6.2 Exploratory Development; Sensors

OBJECTIVE: Demonstrate advanced lightweight antennas that provide array adaptivity and limited electronic scanning while minimizing the number of phase shifters and receivers.

DESCRIPTION: Radars with large aperture antennas have small beamwidths and hence provide good angle accuracy. Conventional phased arrays can provide full electronic scanning and array adaptivity, but for large apertures they require a very large number of radiating elements and active control devices (i.e. phase shifters). This, in turn, leads to heavy and costly arrays. Other methods have been explored in the past that achieve a large aperture system by more efficient means. One such approach would be to use a lens or reflector fed by a multi-beam and/or steerable feed. ARPA is interested in exploring fully adaptive, lightweight surveillance radar array designs for airship and aerostat applications. The array should be fully electronically steerable in azimuth with limited scanning in elevation ($\pm 15^\circ$ to $\pm 20^\circ$). The receiver and transmitter may use the same antenna or separate antennas. The array must be adaptive in both azimuth and elevation, but care should be taken to minimize the total number of receivers.

PHASE I: Propose and evaluate alternate large aperture array concept(s). Model the array performance. Enumerate the array components. Describe the construction approach and estimate the array weight.

PHASE II: Build a prototype section of the lightweight array analyzed in Phase I and demonstrate the key performance parameters.

COMMERCIAL POTENTIAL: U.S. aerostat manufacturers serve an established market both domestically and internationally for both military and commercial applications. For example, systems have been sold to Korea, Iran, and Nigeria as communications nodes and for TV and radio broadcast. Aerostats also have been proposed as long endurance host platforms for remote environmental monitoring in areas such as rainforests. The advancement of lightweight array technology will serve to expand the commercial markets for these systems by providing more capable, lower-cost sensors to serve new markets, such as remote environmental sensing.

REFERENCES:
Antenna Handbook: Theory Applications and Design. Lo, Y.T. and S.W. Lee, editors. Van Nostrand Reinhold Company, New York, 1988, Chapter 19.

ARPA SB961-039 TITLE: Computational Intelligence Approaches to Automatic Target Recognition (ATR)

CATEGORY: 6.2 Exploratory Development; Computing and Software; Command, Control and Communications; Electronic Warfare

OBJECTIVE: Create and demonstrate computational intelligence techniques for model-based Automatic Target Recognition (ATR) systems.

DESCRIPTION: Model-based ATR systems offer great promise in reducing the number of false alarms, while increasing the quality of target classifications. Existing model-based ATR approaches maintain large databases in order to represent each individual target at a number of aspect and depression angles. As the scope of targets to be recognized on the battlefield increases, intelligent approaches to model retrieval and matching are required to achieve real-time system performance. For example, the use of neural networks or genetic algorithms in model matching offers potential in both reducing the training process and creating a parallelized "survival of the fittest" recognition scheme.

The goal of this task is to determine where computational intelligence techniques can be applied to improve model-based target recognition performance, particularly for Synthetic Aperture Radar (SAR) imagery. This task should quantify the possible improvements in contrast to existing approaches and generate a design plan for the implementation and evaluation of the proposed approach. Innovative and novel approaches that go beyond the model-based target recognition paradigm are also of interest.

PHASE I: In detail, define and construct limited prototypes for the technique or algorithm proposed for use in model-based ATR systems. Provide detailed estimates of the technique's impact on ATR computational and functional performance. Research and document the system's applicability to medical and manufacturing vision systems.

PHASE II: Implement the proposed technique or algorithm. Demonstrate, evaluate, and document computational and functional performance gains achieved with the technique or algorithm.

COMMERCIAL POTENTIAL: These methods could have significant commercial impact in lowering costs and improving performance in medical and manufacturing vision systems.

ARPA SB961-040 TITLE: Alternate Power Sources for Aerostats

CATEGORY: 6.2 Exploratory Development; Aerospace Propulsion and Power

OBJECTIVE: Demonstrate advanced aerostat power source technology to provide higher levels of prime power and improved weight efficiency relative to current systems.

DESCRIPTION: Current aerostat systems require from 10 to 30 kVA of prime power to operate the sensor payloads, as well as perform housekeeping functions. Two approaches are currently used. The first is to use an onboard engine/generator (gas or diesel). The second is to employ a "power-up tether." Each method has its advantages and disadvantages. For example, onboard engines require substantial onboard fuel supplies and thus must be brought down periodically for refueling. Power-up tethers, on the other hand, are heavy and require more delicate handling than non-powered tethers. This SBIR request is to study alternate power source techniques and advanced lightweight power-up tethers, and evaluate their effectiveness. This may include, for example, wind generated power, advanced fuel cells, ground-to-aerostat microwave power transmission, etc. The system power levels that are desired range from 30 to 100 kVA and the flight altitudes of interest range from 10 to 25 kft (nominally 20 kft).

PHASE I: Propose and evaluate alternate power generation concept(s). Compare the performance to existing systems. Quantify the improvement. Evaluate feasibility. Consider issues such as payload weight, endurance, drag impacts, and ease of deployment.

PHASE II: Build a prototype of the alternate power generation system analyzed in Phase I and demonstrate the key performance parameters.

COMMERCIAL POTENTIAL: U.S. aerostat manufacturers serve an established market both domestically and internationally for both military and commercial applications. For example, systems have been sold to Korea, Iran, and Nigeria as communications nodes and for TV and radio broadcast. Aerostats also have been proposed as long endurance host platforms for remote environmental monitoring in areas such as rainforests. The advancement of power source technology will serve to expand the commercial markets for these systems by providing more efficient, lighter weight power systems and longer endurance platform performance.

REFERENCES:
11th AIAA Lighter-Than-Air Systems Technology Conference Proceedings, May 15-18, 1995

ARPA SB961-041TITLE: Rapid Target Model Development and Validation

CATEGORY: 6.2 Exploratory Development; Modeling and Simulation; Computing and Software; Command, Control and Communications; Electronic Warfare

OBJECTIVE: Create and demonstrate target model building and target model validation tools that will enable rapid, low-cost creation of target models for Automatic Target Cuing and Recognition (ATC/R) systems.

DESCRIPTION: The construction and validation of models of target vehicles for use in ATC/R systems is time consuming and costly. A typical model build and validate process may take on the order of tens of man months for a complex, multi-step, model building and validation process. The steps are as follows: 1) initial physical CAD model preparation, 2) CAD model validation (comparison of the model to target exemplars to ensure geometric fidelity), 3) augmentation of the physical CAD representation with sensor-specific extensions (dielectric properties for radar or thermal properties for infrared imagery), and 4) sensor-specific validation (extensive comparisons of collected imagery with high-fidelity simulated imagery, derived from the augmented models).

New, innovative and cost-effective methods for building and validating such models are sought, particularly for Synthetic Aperture Radar (SAR) imagery. Such methods will decrease the overall costs of such model building, and radically decrease the amount of time and data needed to create and validate such models. Such methods may include, but are not limited to, techniques from the following list: 1) the creation and validation of SAR-significant models of potential targets using limited amounts and limited views of the target in surveillance imagery, 2) the rapid creation of CAD models of new targets using advanced scanning or survey techniques, 3) the creation of tools and methods for automating the SAR-specific target model validation process, and 4) methods for adapting and/or modifying existing, validated SAR models to represent new, previously unseen targets.

PHASE I: In detail, define and construct limited prototypes for the proposed target model building and validation approach, addressing methods to be employed, data needed for model creation/validation, time needed for creation/validation, and process improvement gains over existing techniques.

PHASE II: Implement the proposed target model building and validation system and demonstrate the improved processes by building target models and documenting process improvement gains.

COMMERCIAL POTENTIAL: These methods will also have significant commercial impact in lowering costs for the creation of high fidelity CAD models for manufacturing and graphical simulation.

ARPA SB961-042TITLE: Development of Holographic Memory for Use In Optical Correlators

CATEGORY: 6.1 Basic Research; Materials, Processes and Structures

OBJECTIVE: Develop a holographic memory that can store several thousand 512x512 images such that all images can be accessed within one second. Parallel access to the images is preferred.

DESCRIPTION: A holographic memory in an optical correlator may be used to store space- or frequency-domain images to be compared or correlated with an input scene in order to detect and classify potential targets within that scene. The holographic memory developed should be capable of satisfying the following parameters: temperature and humidity insensitive when addressing, "write once, read many," a cycle time of one second or less to address all stored holograms, preferably addressable with a minimal power laser source within the wavelength range of 0.6-1.0 microns, and contains few or no moving parts. Furthermore, the design of this holographic memory may be based on wavelength or angular multiplexing schemes. Consideration should be given to achieving minimal bit error rates when addressing the stored images.

PHASE I: Design a holographic memory utilizing existing materials. Provide experimental data showing that the materials chosen are viable to meet the above parameters.

PHASE II: Construct a holographic memory and demonstrate the storage capacity desired with minimal bit error rate upon addressing.

COMMERCIAL POTENTIAL: Volume holographic memory is advantageous whenever there is a need for fast parallel processing of pages of information. It is ideally suited for automatic target recognition for military applications because a holographic memory can parallel process hundreds of scenes, thereby keeping up with the flow of images coming in from sensors. Similarly in industry, holographic memory can be used for identification purposes where processing time is important. Holographic memories are ideally suited for assembly line work where there is a constant flow of input. Robotic vision systems to orient parts on an assembly line are one example. With a robotic vision system, the current orientation of the part can be instantly determined in the same manner that the military's automatic target recognition system identifies targets. The corresponding instruction set can be sent to the robot to re-orient the part precisely to the desired position. Repeated turning and rechecking the part's orientation would not be necessary. A second use is in optical computing. Holographic memories are best for looking at pages of information rather than the traditional computing method of processing bits at a time. Holographic memories are also being looked at for storing large instruction sets and neural networks for optical computers.

REFERENCES:
F.H. Mok, M.C. Tackitt, and H.M. Stoll, "Storage of 500 High-Resolution Holograms in a LiNbO3 Crystal," Optics Letters 16 (8), 605-607 (1991).

ARPA SB961-043TITLE: Non-Linear Optic Materials for Protection of Optical and Electro-Optical Sensors

CATEGORY: 6.1 Basic Research; Sensors, Electronic Warfare

OBJECTIVE: Develop non-linear, optical materials with low switching thresholds, fast (sub-picosecond) switching times and wide dynamic range for protection of optical and electro-optical sensors from high intensity light sources at visible wave lengths.

DESCRIPTION: An intensive effort has been conducted during the past several years to develop materials which display strongly non-linear, optical absorption properties. Organometallic macrocyclic dyes and carbon particles suspensions, for example, are materials which display favorable non-linear properties for application to protection of sensors from laser beams and other intense light sources. However, switching thresholds for these materials are higher than desired, and dynamic ranges are less than desired. There is a requirement for materials with larger, non-linear absorption coefficients and higher damage thresholds. Concepts for producing materials with enhanced non-linear properties by molecular engineering, synthesis of small particle composites, or other approaches are solicited.

PHASE I: Construct/fabricate/synthesize the non-linear material and perform absorption measurements to demonstrate proof of principal.

PHASE II: Improve material properties and thoroughly characterize the intrinsic nonlinear properties of the material. Incorporate the material into a mock-up of a military sensor system and demonstrate effectiveness in protecting the sensor from intense light sources.

COMMERCIAL POTENTIAL: These materials, when successfully demonstrated, have application to safety glasses and other eye protection applications in commercial industry. Lasers are becoming more common place in the manufacturing industry and, as this occurs, eye safety becomes more of a problem, as does the protection of various sensor systems utilized in the manufacturing process.

REFERENCES:
1) M. Sheik-bahae, A.A. Said, and E.W. Van Stryland, "High Sensitivity, Single Beam n_2 Measurements," Opt. Letter, Vol. 14, p.955-957 (1989).
2) M.J. Soilean, T.H. Wel, M. Sheik-bahae, D.J. Hagan, Martine Sence, and E.W. Van Stryland, "Non-linear Optical Charaterization of Organic Materials," Conference Proceedings.
3) Kenneth LaiHing, "Third Order Susceptibility of Silver Sulfide Sol," Technical Report, Contract # DAAH01-92-P-R021, December 1992.

4) Kenneth LaiHing, "Third Order Susceptibility of Silver Sulfide Colloid," Technical Report, Contract # DAAH01-92-P-R021, December 1992.
5) Kenneth LaiHing, "Third Order Susceptibility of Platnium Sulfide Sol," Technical Report, Contract # DAAH01-92-P-R021, December 1992.
6) Kenneth LaiHing, "Third Order Susceptibility of Gold Sulfide Sol," Techncial Report, Contract # DAAH01-92-P-R021, December 1992.

Requests for the last four technical reports should be referred to (703) 696-2448.

ARPA SB961-044TITLE: Millimeter Wave/Infrared Dichroic Beam Combiner

CATEGORY: 6.2 Exploratory Development; Materials, Processes and Structures

OBJECTIVE: Develop samples of dichroic beam combiner materials which transmit millimeter wave electromagnetic waves and reflect infrared light.

DESCRIPTION: Missile systems simulation activities require a dichroic beam combiner element for inclusion in an existing millimeter wave (MMW), hardware-in-the-loop (HWIL) simulator which will transmit MMW electromagnetic plane waves while simultaneously reflecting collimated Infrared (IR) light. This modification to the MMW simulator will allow HWIL simulations to be executed in support of dual-mode common-aperture MMW/IR guided missile system development. The approach taken will result in the ultimate development of dichroic elements which are efficient at transmitting MMW and reflecting IR, and which can be manufactured with physical sizes of at least three feet by three feet.

PHASE I: Produce samples of dichroic beam combiner materials for MMW and IR characterization. Demonstrate that the sample sizes can be grown to meet the ultimate size requirements indicated.

PHASE II: Develop larger samples of the materials which can be readily integrated into an existing MMW simulator for use in HWIL simulations of dual-mode common-aperture MMW/IR guided missile systems.

COMMERCIAL POTENTIAL: Dichroic beam combiners are required for the next generation of Earth Resources satellites that are being developed by NOAA and private industry. A dichroic beam combiner makes it possible to simultaneously collect energy from two separate parts of the spectrum through a common aperture. A common aperture offers the advantage of size and weight efficiency, and minimizes image registration problems. Remote sensing and processing of multispectral signatures will provide significant improvement in important areas, such as: evaluation of crop states; estimation of the water content of the soil and atmosphere; presence of pollution agents in the atmosphere, streams, and rivers; imminence of volcanic eruptions; extent of forest fires; and any other phenomena that can be properly observed only by high altitude, remote sensing platforms. This SBIR task has a very high potential for developing efficient, expensive, and lightweight dichroic beam combiner technology that can be applied to remote sensing applications.

REFERENCES:

S.B. Mobley, "U.S. Army Missile Command Dual-Mode Millimeter Wave/Infrared Simulator Development," Characterization, Propogation, and Simulation of Sources and Backgrounds IV, SPIE Proceedings, Vol. 1967, April 1994.