ADVANCED RESEARCH PROJECTS AGENCY

Submission of Proposals

The responsibility for carrying out ARPA's SBIR Program rests with the Office of Administration and Small Business. The ARPA Coordinator for SBIR 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 in the Office of Administration and Small Business and distributed to the appropriate technical office for evaluation and action.

ARPA has identified 87 technical topics, numbered ARPA 93-033 through ARPA 93-119, to which small businesses may respond in the second fiscal year (FY) 1993 solicitation (93.2). Please note that these are the only topics for which proposals will be accepted at this time. Proposals can no longer be accepted on those previously advertised 32 technical topics which were numbered ARPA 93-001 through ARPA 93-032. A list of the topics currently eligible for proposal submission is included below, followed by full topic descriptions. The topics originated from ARPA technical offices.

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, as well as, dual-use applicability as the budget and other factors will allow. In the early years of the SBIR program most of the promising Phase I proposals could be funded, but as the program's popularity increased, this became more and more expensive. ARPA therefore instituted program changes to fund more Phase Is. These included increasing the number of SBIR topics, and setting more funds aside for Phase I proposals. In order to do this and still have a reasonable amount of funds available for the further development of promising Phase Is, the Phase II awards are limited to $375,000; however, additional funding may be available for optional tasks.

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 proposals 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 can only respond to one topic.

ARPA has prepared a checklist 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. Do not include the checklist with your proposal.

ARPA 1993 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. Post Potential Applications __________

i. Key Personnel __________

j. Facilities/Equipment __________

k. Consultants __________

l. Prior, Current, or Pending Support __________

m. Cost Proposal - Appendix C __________

2) Bindings

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

b. <u>Do not</u> use a cover. __________

c. <u>Do not</u> use special bindings. __________

3) Page Limitation

a. Total for each proposal is 25 pages inclusive of cost proposal (Appendix C) 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. __________

SUBJECT/WORD INDEX TO THE ARPA SBIR SOLICITATION

Subject/Keywords **Topic No.**

INDEX OF ARPA FY 93 TOPICS

ARPA 93-058 Agile, Laminar Fabrication of Mixed-Material Structure

ARPA 93-059 Distributed, Unattended Sensor Networks

ARPA 93-060 Microactuator Arrays for Small-Area Displays

ARPA 93-061 Develop Exercise Software to Run on ARPA JANUS-3D Wargame in UNIX Environment

ARPA 93-062 Develop Low-Cost Reconfigurable Combat Vehicle Simulators for National Guard

ARPA 93-063 Artificial Intelligence Mimic/Tutor

ARPA 93-064 Development of Interactive Computer-Based Training Programs for Home Use

ARPA 93-065 Low-Cost Techniques to Prevent Enemy Use of Captured Personal Communication Equipment

ARPA 93-066 Low-Cost, Add-On Guidance and Control Concepts for Artillery Projectiles or Rockets

ARPA 93-067 Application of Thermoplastics for Lightweight Survivability

ARPA 93-068 Self-Repairing Materials for Vehicle Survivability and Structural Applications

ARPA 93-069 Smart Materials and Active Structures in Light Combat Vehicles

ARPA 93-070 Parametric Approach to Concept Exploration in Distributed Simulation

ARPA 93-071 Innovative Approaches to Linking Wargames

ARPA 93-072 High-Speed Electrodes for High-Density Optical Guided Wave Devices

ARPA 93-073 Multisensor Inspection for Microelectronics

ARPA 93-074 Residue Number-Based Fast Fourier Transformers (FFTs)

ARPA 93-075 Parallel Infrared (IR) Magneto Mapper for Semiconductor Material

ARPA 93-076 Optical to Electrical Power Conversion Unit

ARPA 93-077 Payout Dynamics Experimental Investigation

ARPA 93-078 Compact Acoustic Plane Wave Generator

ARPA 93-079 Thrust Vector Control (TVC) System for Low-Cost Expendable Turbojet Engines

ARPA 93-080 High-Strength Bend-Insensitive Polarization Maintaining (PM) Fiber Development for Inertial Sensor Applications

ARPA 93-081 Micro-Lasers for Infrared Scene Projection

ARPA 93-082 Automated Bobbin-Baselayer Inspection System

ARPA 93-083 Models for the Growth and Processing of Infrared (IR) Materials

ARPA 93-084 Process Control Technology for Infrared (IR) Materials Growth and Device Fabrication

ARPA 93-085 Processes and Equipment for Advanced Devices

ARPA 93-086 Simulation Tools for Plasma Reactor Synthesis

ARPA 93-087 Chemical Vapor Deposition (CVD) of Next Generation High Density Interconnects

ARPA 93-088 Lenses and Mirror Technology for X-ray Lithography

ARPA 93-089 Stress-Free Membranes for Submicron Stencil Mask

ARPA 93-090 Photoconductive Switch for Reconfigurable Antenna

ARPA 93-091 Simulation, Modeling and Computer Aided Design (CAD) Tools for Optoelectronic Components

ARPA 93-092 Applications Demonstration Utilizing Optical Computing

ARPA 93-093 Lightweight, Hand-Held Gamma Ray Detector with Isotope Identification Readout

ARPA 93-094 Gamma Ray Lens Feasibility Study

ARPA 93-095 Lightweight, Hand-Held Chemical Detector with Chemical Identification Readout

ARPA 93-096 Optimization of Real-Time Communications for a Global Nuclear Proliferation Monitoring System

ARPA 93-097 Assessment of Techniques for Nuclear Testing that Evade Detection, and Development of Monitoring Approaches to Counter such Evasion Attempts

ARPA 93-098 Laboratory and Theoretical research to Predict Decoupling Effects for Various Comprehensive Test Ban Treaty Evasion Schemes

ARPA 93-099 Photonic Radar Systems

ARPA 93-100 Interference Rejection and Angle Estimation Techniques for Antenna Arrays with Uncertain Element Locations

ARPA 93-101 Electrooptic Materials Development

ARPA 93-102 Develop Ground Bounce Jammer Mitigation Techniques for Communication and Radar Systems Implementation

ARPA 93-103 Lattice Wing Technology for Maneuverable Towed Bodies

ARPA 93-104 Photonic Hybrid Devices for Radar and Communications Systems

ARPA 93-105 Knowledge Query and Manipulation Language (KQML) Interfaces

ARPA 93-106 Methods to Extract Annotations from Engineering Drawings and/or Maps

ARPA 93-107 Methods, Support, and Languages to Control, Access, and Integrate Results of Simulation Programs from Remote Systems

ARPA 93-108 Means to Facilitate Access to Public or Semi-Public Databases from Remote Systems

ARPA 93-109 Advanced Multimedia Imaging Helmets

ARPA 93-110 Intelligent Robotic Cranes and Fixtures for Manufacturing of Ship and Ship Systems

ARPA 93-111 Advanced Marine Internal Combustion Engines

ARPA 93-112 Intelligent Planning and Control Systems for Rapid Response and Mitigation of Maritime Oil Spills

ARPA 93-113 Advanced Embedded Sensors and Intelligent Control Systems for Internal Combustion Engine Performance Monitoring and Control

ARPA 93-114 Dolphin/Bat Signal Processor and Classifier

ARPA 93-115 Dolphin Sonar Transducer and Array

ARPA 93-116 Sensors and Technologies for Fiber-Optic Sensing Systems

ARPA 93-117 High-Density and Safe Storage for Unmanned Undersea Vehicles and Electric Land Vehicles

ARPA 93-118 Compact and Efficient Reformer to Supply Hydrogen for Proton Exchange Membrane (PEM) Fuel Cell Stacks

ARPA 93-119 Components for Low-Cost, High-Performance and Robust Proton Exchange Membrane (PEM) Fuel Cells

ARPA 93-033TITLE: Innovative Approaches to the Design of Visually Covert Low-Power, Low-Gain Antennas in the Range of 2-2000 MHz

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Design, simulate, implement and demonstrate a family of small, covertly-concealable, mobile receiving and/or transmitting antennas, covering selected portions of the 2-2000 MHz band.

DESCRIPTION: Concepts are sought for a family of small, visually-covert antennas that can be installed in mobile platforms such as automobiles, trucks, aircraft, trains, boats or shipping containers to provide transmission of position and other information about the state of the mobile platform. The antennas must also be capable of receiving command messages and transmitting state data to a command center. The antennas should cover selected portions of the HF, VHF and UHF frequency bands. HF includes near-vertical incidence and long-range capabilities. VHF includes meteor burst communication, line of sight and diffraction/mixed modes. There are two classes of antennas to be considered: Class (1) where modest preparation of the mobile platform is permitted before use; Class (2) where little to no preparation of the mobile platform is permitted before use. The maximum peak power to be transmitted is 20 watts. For reception in the lower VHF and HF bands, the receiving sensitivity should be no worse than quasi-minimum or Galactic noise, whichever is greater. Criteria for evaluating competitive designs will include efficiency, covertness to visual detection, ease of installation into a variety of platform types (different designs for each type of platform and frequency band are acceptable), ruggedness and gain. Designs for directional antennas shall include the means at both ends of a communication link for tracking the command station.

Phase I: Design a family of antennas to support the description above. Model and/or simulate the performance of the antennas. Generate a report that: analyzes the efficiency of each of the antennas, includes graphics showing the way covertness will be achieved and how installation in each of the types of mobile platforms will be performed, and shows antenna patterns in the vertical and horizontal planes over the band of frequencies selected.

Phase II: Implement a mutually agreeable set of full-scale antennas. Deliver and support the installation of the antennas into a selected subset of government-furnished mobile platforms. Prepare a test plan for the evaluation of the communication performance of the antennas as installed in a selected subset of mobile platforms. The other portion of the communication system will be provided by the government. Support the field test with personnel and/or automated data collection capabilities at up to three test sites simultaneously, at least one of which will be mobile. Prepare a final report on the field tests.

ARPA 93-034TITLE: Innovative Approaches to Radar Detection of Underground Targets

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Investigate and demonstrate innovative approaches for the detection and recognition of underground targets with radar systems.

DESCRIPTION: The detection of underground targets has long been an area of active interest to the DoD and, more recently, to various civil agencies for law enforcement and environmental purposes. Radar has always been a sensor of interest because of the earth-penetration properties of low-frequency radiation and the inherent potential for day/night, high search rate, highly automated imaging systems. Despite these characteristics, high-performance systems have not been produced because of various implementation challenges, physical limitations, and difficulty in the recognition of targets and suppression of surface and subsurface clutter. In light of advances in radar technology, signal processing, and automated image processing, ARPA is interested in innovative concepts which may offer useful performance. All target classes are of interest, ranging from small objects at shallow depths, such as mines, through intermediate targets such as arms caches, to very large underground facilities at perhaps great depths. Surface conditions may range from desert to foliated and rough terrain. Topics of interest include complete system concepts, radar subsystems or components which offer some unique contribution to underground target detection, and signal or image processing techniques which enhance target detection/recognition and aid in clutter suppression. System concepts may include airborne or ground-based, vehicle-mounted or non-portable radars.

Though such systems are likely to operate at lower frequencies, perhaps L-band or lower, and would have bandwidths and cross-range processing approaches commensurate with resolution/target size considerations, alternative techniques and innovative implementations are also of interest.

Phase I: Phase I tasks would generally consist of system design and performance prediction, but could include laboratory demonstrations or field experiments in relation to critical technical issues.

Phase II: Phase II would include upgraded system design/optimization, with supporting laboratory or field experiments, and the field demonstration/verification of the full system, though not necessarily in an operational configuration.

ARPA 93-035 TITLE: Terrain and Geologic Feature Extraction from Synthetic Aperture Radar (SAR) Imagery

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop techniques to automatically extract terrain and geologic features, including height, from both two-dimensional and three-dimensional SAR imagery.

DESCRIPTION: SARs have been used for a number of years for military and civil applications. ARPA has recently embarked upon a two-pronged technology development effort to extend and enhance performance in these applications through exploitation of interferometric SAR (IFSAR) techniques. IFSAR processing adds a third dimension to SAR products -- elevation -- which enables extraction of Digital Terrain Elevation (DTE) data which can be used in terrain analysis. IFSAR signal processing involves the creation of two or more SAR images simultaneously from different points in space while preserving the relative phases for each pixel in the map. The phase differences between the multiple SAR images can then be used to provide an estimate of the height and/or velocity of each pixel. Thus, IFSAR provides range, cross-range and elevation. This added third dimension allows for the creation of accurate three-dimensional records of the scenes being viewed. In addition to the IFSAR DTE data, the two-dimensional SAR imagery itself provides a valuable product. SAR imagery shows roads, buildings, vehicles and other landmarks. Thus, it should be possible to automatically extract these and other natural and man-made features from the imagery. This extraction is currently done to some limited degree in Automatic Target Recognition (ATR) systems, where the terrain and geologic features are generally classified as clutter. In this case, ARPA is interested in the extraction and identification of classes of terrain and geologic features such as forest type, soil moisture content and surface roughness.

Phase I: Phase I generally consists of developing techniques for automatically extracting terrain and geologic features from SAR imagery, and performance prediction of those techniques. However, it could also include laboratory demonstrations or field experiments in relation to critical technical issues, or for performance prediction.

Phase II: Phase II would include improving upon the techniques identified/developed during Phase I, with supporting laboratory or field experiments, validation of algorithm performance, and the implementation of the extraction techniques in a workstation environment.

ARPA 93-036 TITLE: Modeling and Simulation of Multimedia Transmission Over Wireless Networks

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop models for transmission of multiple data formats (data, image, video, voice) over wireless networks and simulate performance of these models.

DESCRIPTION: Research and develop methods and techniques for multimedia transmission over wireless networks. Hardware and software solutions are sought that are capable of running with general-purpose, scalable computing environments and that can deliver multimedia over limited distances without physical connections (wire or optical fiber). Limitations, domains, and applicability of the approach must be quantified. Demonstrations should be consistent with the goals of the Federal High Performance Computing and Communications (HPCC) program.

Phase I: In detail, define the model, including channel and source coding techniques, interfaces, trade-offs, and risks. Expected performance must be estimated, along with comparisons to existing state of the art.

Phase II: Develop, prototype, demonstrate, and deliver the simulator, as well as associated documentation and testing strategy that compare results to predictions.

ARPA 93-037 TITLE: Mobile Connectivity to National Networks

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Explore, develop, and demonstrate innovative methods for providing computer networking access and services between mobile hosts and the National Research and Education Network (NREN).

DESCRIPTION: Research and develop innovative wireless communication technologies, network protocols interfacing mobile host computers to the NREN, file services and other utilities, for use by detached hosts who are outside of the relevant service area(s). While inside the service area, it is required that network connectivity be maintained while hosts are permitted to relocate at pedestrian speeds or faster. Preference will by given to approaches that exploit existing standards, such as network protocols and file system interfaces, and which exhibit potential for scaling to large numbers of hosts. Specifically excluded are technologies and protocols that are limited to in-building replacement of conventional network cabling between desktop computers.

Phase I: In detail, define the candidate communications technology, network protocols, file services and utilities, technical approaches, interfaces, trade-offs, and risks in comparison to existing approaches, along with supporting evidence of success, such as early feasibility analyses or prototyping experiments.

Phase II: Prototype, develop, demonstrate, evaluate and deliver network interfaces, protocol implementations, or file services and utilities along with associated documentation and evidence or performance evaluations that compare results to original predictions.

ARPA 93-038 TITLE: Security Protocol Design for Networks

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop and prototype novel and effective computer/network security protocols and tools for use within the Internet environment.

DESCRIPTION: General -- Concepts are sought for innovative and novel ideas and implementation of protocols that enhance secure or high-assurance computer operation over computer networks. Protocols may be targeted at various network applications including, but not limited to, secure implementation of: network management, electronic mail, remote login, remote procedure calls, distributed file systems, and multi-media. Tools include, but are not limited to, implementation of privacy and authentication techniques, and cryptographic techniques. Implementations may be targeted at workstation-class machines or scalable high-performance computing platforms with Unix, Posix or Mach-based operating systems. Protocols should be targeted for use within the Internet. Interfaces to protocols must be open and non-proprietary, as well as suitable for publication as Internet Request For Comment (RFC).

Phase I: Provide a detailed specification of the proposed protocol (including a draft RFC suitable for general comment), tool, or algorithm. Describe new or novel ideas or concepts. Describe the concept's or idea's key features. Demonstrate or describe how the new protocol, tool, or algorithm would be used. Finally, describe the path or process for implementation within one of it's intended target platforms.

Phase II: Develop the protocol, tool, or algorithm that implements the new technology, concept, or idea. Demonstrate the effectiveness of the new technology. Provide documentation that clearly describes how to use it, any external interfaces or requirements, and the system interface. A hardcopy and a magnetic media copy of the code are required. The magnetic media is to be delivered in Unix Tar format, with all sources in ASCII.

ARPA 93-039 TITLE: Scalable Accelerators and Interfaces for High-Performance Computing Systems

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop and quantify performance of specific hardware/software accelerators that will operate as part of a scalable high-performance computing system environment.

DESCRIPTION: Research and development of specific, small-scale, hardware accelerators or techniques is sought. Hardware and software solutions, capable of running in collaboration with general-purpose scalable computing environments, are sought which can accelerate classes of computational problems by 2-3 orders of magnitude over general-purpose solutions. The ability to rapidly prototype the accelerators is essential. Preference will be given to approaches exploiting existing standards, open interfaces, and future-generation scalable technologies. Limitations, domains, and applicability of these approaches must be quantified. Demonstrations should be consistent with the goals of the Federal High Performance Computing and Communications (HPCC) program, and be focused on high-payoff application areas.

Phase I: In detail, define the candidate accelerator, technical approaches, interfaces, trade-offs, and risks, along with supporting evidence of success, such as early prototyping experiments. Comparisons should be made to existing state of the art, and expected performance should be related to trends and general-purpose solutions.

Phase II: Prototype, develop, demonstrate, and deliver the accelerator, as well as associated documentation and testing strategy that compare results to predictions.

ARPA 93-040 TITLE: System and Technology Computer Aided Design (CAD) on a Scalable Computing Base

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Research and develop new algorithms to support computing system and electronic technology CAD that can potentially execute on both workstations and massively parallel computers.

DESCRIPTION: New algorithm families implemented in design tools are sought for use in approaches that will lead to innovations in Technology Computer Aided Design (TCAD) and to the design of new computing systems. These algorithms will provide the design foundation for the next generation of advanced electronic devices, processes, and microsystem components, and thus they must be capable of executing on diverse computing systems that range from workstations to massively parallel computers. Such algorithms should support the goals of the Federal High Performance Computing and Communications (HPCC) program.

Phase I: In detail, define the application, algorithm(s), trade-offs, and comparison with existing approaches, and provide supporting evidence of success, such as early prototyping experiments or simulation results.

Phase II: Develop and demonstrate a tool implementing the algorithm and provide supporting documentation and test cases which clearly demonstrate its feasibility. Evidence that it is capable of running and performing for scalable parallel computing purposes is required.

ARPA 93-041 TITLE: Software Technologies for Advanced High-Performance Computing Environments

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Explore novel ideas for advancing scalable high-performance computing environments to dramatically improve programming and user productivity.

DESCRIPTION: General -- Concepts are sought for innovative ideas to advance high-performance computing environments. The list of desired advancements/developments includes, but is not limited to, compiling technology for scalable parallel computers; tools to support development of scalable parallel programs; tools for visualizing, measuring, profiling, analyzing, and debugging parallel programs; run-time system technology, tools, or libraries; scalable algorithms for application software library modules; and novel concepts for supporting scalability in either run-time or application libraries. Concepts must be described at a high enough level to be system independent and have clearly defined and open interfaces. Focus should be on scalable computing systems. Collaboration with ongoing research in academia, government laboratories, or industry is encouraged.

Phase I: Provide a detailed specification of the proposed concept, principle, or algorithm. Describe new or novel ideas or concepts. Describe the concept's or idea's key features. Demonstrate or describe how the new concept, principle, or algorithm would be used. Finally, describe the path or process for implementation on advanced processors or scalable parallel systems.

Phase II: Develop the software prototype, subsystem, or module which implements the new technology, concept, or idea. Demonstrate the effectiveness of the new technology. Provide documentation that clearly describes any external interfaces or requirements, how to use the software module, and the system interface. A hardcopy and a magnetic media copy of the code are required. The magnetic media is to be delivered in ASCII form and must be in Unix Tar format.

ARPA 93-042 TITLE: Integrated Computer Aided Design (CAD) Package for Designing Precision Antennas

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop a CAD package for the design of antennas which must simultaneously meet stringent electromagnetic, mechanical, and environmental requirements. The CAD package is to use a common representation of the antenna for conducting engineering trade-offs between electromagnetic and environmental requirements.

DESCRIPTION: CAD packages exist that permit the design of many types of antennas to satisfy very precise electromagnetic requirements with respect to pattern, input impedance, etc. In many defense requirements, the antennas are subject to severe environmental conditions, and these conditions can significantly affect antenna performance. While CAD packages exist that permit determination of changes in antenna physical properties (dimensions, temperature, etc.), these changes are not related to electromagnetic properties without extensive additional analysis and data reformatting. This project will select one or more small antenna types, as are commonly used for array elements or alone, and then determine suitable analysis methods for the antennas' electromagnetic, mechanical, and thermal properties. The analysis methods should be able to use a common representation of the antenna. A design methodology will be developed that uses sensitivity analyses of the effects of mechanical stress, temperature changes, etc., on antenna electromagnetic performance to form the foundation for trade-off studies, which culminate with antenna designs that are insensitive to environmental effects. The resulting CAD package should be designed for use in a workstation environment. Also, the resulting CAD package should have its calculation results extensively validated, and should compare computed results to experimental data. At the end of the project, one or more antennas shall be designed, fabricated, and tested to demonstrate the utility of the CAD package.

Phase I: Select antenna type(s) to be the focus of the proposed CAD package. Determine analysis methods to be used for electromagnetic, mechanical, and thermal properties of the antenna(s), and the design representation which will be common to all analyses. Determine design methodology and method of doing sensitivity analyses and trade-offs, and develop the CAD package's architecture. Identify the availability of experimental data for validation of calculations, and develop a validation plan. Identify the antenna type(s) to be built for validation under Phase II. Demonstrate the appropriateness of the selected analysis methods, design representation, and design methodology by running test-case designs using existing nonintegrated methods.

Phase II: Using the results of Phase I, develop an integrated CAD package and associated user documentation, conduct the validation plan, and design, build, and test the antenna type(s) selected for CAD package validation under Phase I.

ARPA 93-043 TITLE: Low-Cost Fiber Optics to Computer Interface

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop and test a fiber-optic cable to Personal Computer (PC) connector technology that could be mass produced and installed for a price comparable to that of a coaxial cable connection.

DESCRIPTION: Fiber-optic local area networks offer great potential for improving the capability of deployable military command and control systems because they permit improved performance, while at the same time reducing volume and weight. Unfortunately, the difficulty and expense of making fiber-optic connections is a deterrent. Existing fiber-optic connection techniques are expensive, tend to be fragile, often require careful alignment, and are susceptible to dirt. The goal of this project is to seek innovative methods for overcoming the drawbacks of fiber-optic connections as applied to small computers (eg. PCs). Emphasis should be placed on reducing the cost per connection (when bought in bulk) to a cost comparable to that of conventional coaxial connections.

Phase I: Develop several innovative methods for connecting an optical fiber to a small computer when the optical fiber is to support a standard local area network, and analyze their expected performance and projected cost. Based on the results of the analysis, select the most promising concept for further investigation.

Phase II: Build and test a prototype of the connector concept selected in Phase I and validate the assumptions made in the Phase I analyses.

ARPA 93-044 TITLE: Integrated Micromechanical Sensors and Actuators for Vibration Control

CATEGORY: 6.1 Basic Research

OBJECTIVE: Develop an integrated system using micromechanical sensors and micromechanical actuators that can control the lower-order vibrational modes of a rotating shaft or of a thin plate or membrane.

DESCRIPTION: Micromechanical sensors have been developed to the point of widespread practical application, and micromechanical actuators have been demonstrated in the laboratory. As a result, great potential exists for novel systems and applications arising from combining these two elements in integrated systems. In order to explore this potential, this program will develop an integrated micromechanical sensor/actuator system that can control the lower-order vibrational modes of either a rotating shaft or of a thin flat plate or membrane. The intended final application is either to permit higher-speed operation of rotating machinery, or to reduce acoustic noise radiated by a machinery enclosure.

Phase I: Develop architectural concepts for an integrated micromechanical system, model and simulate their performance, and examine suitable manufacturing processes for systems for both of the proposed cases (rotating shaft and flat plate). Based on these results, decide on a particular concept to be developed in Phase II and document the rationale for the choice.

Phase II: Develop a detailed design for the concept selected in Phase I, and fabricate and test a prototype.

ARPA 93-045 TITLE: Automated Generation of Electromagnetic Computer Aided Design (CAD) Package Computational Meshes

CATEGORY: 6.1 Basic Research

OBJECTIVE: Develop one or more algorithms for the automated generation of computational meshes used for solving numerical electromagnetics problems, and an associated methodology for assessing the computational errors associated with the automatically-generated mesh.

DESCRIPTION: Numerical electromagnetics analysis capabilities have significantly increased in the past decade due to the availability of high-performance computers and the development of several effective analysis methods (Method of Moments, finite elements, finite difference, time domain, etc.). However, application of numerical electromagnetics analysis methods to complex or large objects requires extensive geometric modeling of the object followed by definition of the appropriate computational mesh. Due to the nature of electromagnetics problems, automatic mesh generators developed for other applications (mechanical design, computational fluid dynamics, etc.) are not well adapted to electromagnetics problems that require hand refinement of the meshes. This project is to develop one or more algorithms (Method of Moments, finite elements, etc.), starting from a CAD file description of a complex object, and to develop an accompanying error analysis, relating features of the automatically generated computational meshes to errors in the subsequent numerical electromagnetics calculations. The capabilities of the developed algorithms will be assessed by using them to calculate electromagnetic quantities for complex objects for which theoretical results and/or experimental data exists, and then comparing the calculated results with the theoretical and/or experimental results.

Phase I: Survey automatic mesh-generation algorithms and numerical electromagnetics algorithms. Analyze the effects of computational mesh properties on numerical electromagnetics errors, and select one or more combinations of mesh-generation/numerical electromagnetics algorithms for development and refinement. Develop a plan for validating and demonstrating the performance of the selected mesh-generation/numerical electromagnetics combination using theoretical and experimental results. Conduct a preliminary assessment of the selected mesh-generation/numerical electromagnetics combination.

Phase II: Complete development of the selected mesh-generation algorithm, resulting in an executable computer code. Complete development and documentation of the error analysis relating automatically-generated mesh properties to subsequent numerical electromagnetics calculation errors. Conduct the validation and demonstration plan developed under Phase I.

ARPA 93-046 TITLE: Encapsulated Sensing Subsystems for Telemetry and Remote Control

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop a sensor encapsulation system and associated data telemetry which permit selected physical variables to be remotely sensed in hazardous or inaccessible locations and the resultant measurements to be processed by standard instrumentation.

DESCRIPTION: The properties of advanced materials could be improved and their cost reduced if the manufacturing process was under closed-loop control. This project is to establish the feasibility of developing a family of sensors which could measure and provide feedback on material properties and/or process variables, while directly accompanying material samples through the manufacturing process. The sensors would be encapsulated to withstand the environmental stresses associated with taking *in situ* measurements, would provide outputs compatible with existing information-processing equipment and standards, would be self-contained (providing their own power source), and would use a wireless telemetry system to report their measurements. The intent is to minimize interfaces and supporting equipment needed to use the sensors. The sensors' conceptual design should seek to minimize the expected cost of producing the sensors, so that reuse is not required in order to achieve economic feasibility, and so that sensor maintenance would be minimal. The project will select a single materials manufacturing process and two or three physical or chemical measurements to use while investigating the concept's feasibility. If feasible, the initial phase would be followed by the building and testing of a small number of prototype sensors.

Phase I: Determine a candidate materials manufacturing process and physical and/or chemical measurements to be performed. Define the operational environment of the sensor package. Based on this information, develop a conceptual design for the encapsulated sensor system, which should include sensor mechanisms, calibration requirements and procedures, power source, telemetry and control, environmental encapsulation concept, and interface with standard information-processing equipment.

Phase II: Develop and test prototype encapsulated sensors based on the conceptual design of Phase I.

ARPA 93-047 TITLE: Solid Freeform Fabrication

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Develop and demonstrate the machine capability to produce functional prototypes directly from Computer Aided Design (CAD) files without part-specific tooling or operator intervention. Materials of interest include: monolithic structural ceramics, fiber composites, and Functionally Gradient Materials (FGMs).

DESCRIPTION: The choice of materials for construction is made at the system level, in most cases at the preliminary design stage. At this stage, advanced materials are at a distinct disadvantage relative to lower-cost commodity materials that are often available in billet stock form which can be fabricated into finished prototypes with readily available machine-shop capabilities. Solid Freeform Manufacturing (SFF) is commercially available for plastics, where it is used for `form and fit' and, increasingly, for low-cost rapid tooling. Extending this technology to functional prototypes made from monolithic structural ceramics, fiber composites, or FGMs will help make these materials more user friendly to the system-level designer by reducing the time and cost of producing functional prototypes. To be of greatest benefit, the material properties (strength, elastic modulus, fracture toughness, etc.) obtained by using the SFF capability must match those obtained by using the conventional manufacturing methods which would be used for high-volume production of the prototyped parts. Extension of the machine capability to components or devices for which the composition will vary spatially is also of interest.

Phase I: Demonstrate the SFF machine capability for the fabrication of functional prototypes from monolithic structural ceramics, fiber composites, or FGMs. Demonstrate both the ability to fabricate near-net-shape components, and that the strength of the materials produced is comparable to that of materials fabricated by conventional methods.

Phase II: Expand upon the machine capability demonstrated in Phase I to determine the effect of machine operating conditions on part tolerances, material microstructure/property relationships (including strength), component build rate, and component costs.

ARPA 93-048 TITLE: Integration of Large-Scale Simulation and Controls

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop methods for control of physical processes, especially complex processes occurring during materials processing, which employ physically-faithful simulations in the construction of models.

DESCRIPTION: Considerable effort has been spent developing simulation codes for a variety of complex physical processes. Recently, experience developing computational fluid dynamics and combustion codes has been applied to efforts to develop codes that simulate a variety of complex physical processes, such as those occurring in processing of materials (e.g., chemical vapor deposition). Such codes will prove useful for design of processes and in testing. However, many such processes require on-line control to achieve processing requirements and, while models exist for many of the complex processes of interest and simulation codes are being developed, novel approaches may nonetheless be required in order to use this information to develop robust methods for sensor-based feedback control. ARPA seeks novel approaches, based on physical models and/or large-scale simulations, to development of sensor-based feedback control methods for manufacturing or materials processes of interest. Work should focus on the interface between physically-faithful computational simulations and on-line control. Two features need to be addressed: development of appropriate software tools and validation on at least one process of interest to DoD. In addition, it is desireable that this be done within an analytic framework to enable an assessment of robustness, modeling error, and effect on control.

Phase I: Develop a methodology for constructing sensor-based feedback controls using large-scale simulations. Development should focus on a problem in materials processing of critical interest to DoD. Demonstrate the methodology's feasibility.

Phase II: Develop algorithms and software, demonstrate approach, and validate on specific process.

ARPA 93-049 TITLE: Flexible Manufacturing of Laser Diode Arrays

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop flexible manufacturing methods for laser diode arrays in integrated packages for many applications. Manufacturing processes should reduce the cost associated with making different types of packages.

DESCRIPTION: Laser diode technology has matured in many ways over the last several years. The device performance has increased dramatically, enabling many different types of applications. These applications cover a wide range of performance and architectural requirements. The thermal and optical systems that are an integral part of the package are driven into quite different regimes depending on the specific application. For example, the duty factor, which can range from 10 Hz to CW, would require many different types of coolers. Similarly, in optical subsystems the requirements range from no optical elements to complicated arrangements of microlenses and fiber coupling requiring precision assembly. A flexible manufacturing approach that would allow all the package architectures to be produced on the same manufacturing line would reduce the cost of producing different types of packages. Rather than having multiple fixturing and tooling for each type of package, a flexible line would allow most of the assembly to be done with the same tooling system.

Phase I: Assess both DoD and commercial applications in terms of requirements on package architectures and recommend ways in which a flexible manufacturing process would reduce the cost associated with making laser diode array packages incorporating different types of cooling systems and optical systems.

Phase II: Implement the concepts developed in Phase I into a common manufacturing line and demonstrate cost reductions.

ARPA 93-050TITLE: Innovative Applications of Fiber Optics in Biomedical Technology

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Broaden the use of fiber optics in biomedical technology.

DESCRIPTION: Fiber optics has emerged as the key technology in the next generation of telecommunications. Its success is due to many of its characteristics, including its: high bandwidth, high efficiency, compactness, light weight and flexibility. In the biomedical area, fiber optics have successfully been used for endoscopic surgery and photo dynamic therapy. However, the potential uses for fiber optics in the biomedical arena are still largely untapped. For example, in endoscopic surgery a three-dimensional image is still lacking. By taking advantage of the physical properties of fiber optics (compactness and flexibility) and combining it with modern optics and advanced software algorithm, a three-dimensional image of the surgical area could be generated. Fiber optics might also be used in conjunction with frequency tunable lasers, for example, diode-pumped solid-state lasers, to deliver laser energy with the appropriate wavelength to desired tissue or organs. In addition, the high bandwidth property of fiber optics is not yet used in biomedical technology.

Phase I: Conduct a trade-off study of fiber optics for one or more specific areas of application in biomedical technology. A projection of technical and cost benefits and a program plan are required. Include some discussion about the transition to this technology.

Phase II: Conduct a proof-of-principle demonstration of idea(s), initially in the laboratory with a follow-up demonstration in a testbed or, preferably, in a medical facility.

ARPA 93-051TITLE: Efficient Processing of Logistic Fuels for Military Fuel Cells

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Explore innovative ideas for more efficient processing of logistic fuel for militarized fuel cells.

DESCRIPTION: Depending on the particular fuel cell technology involved, today's fuel cells operate on either pure gaseous hydrogen, or on mixtures of hydrogen and carbon dioxide with small amounts of carbon monoxide and sulphur impurities tolerated. Large-scale use within the Military depends on the development of an efficient method for converting common logistic fuels, i.e. DF-2 and JP-8, into such a gaseous fuel mixture. Proposals are sought for new and innovative approaches to pre-processing these fuels for use in conventional steam reformers and for novel overall processing concepts that maximize fuel conversion and power system efficiency. Proposals should discuss the application of the proposed concept to the major fuel cell technologies under development and concepts that apply to more than one of the major fuel cell technologies will be favored. Other considerations that should be discussed include: fundamental materials issues, transient response, part-load efficiency, emissions, economics, and life-limiting factors.

Phase I: Submit preliminary fuel-processing system designs, performance thermodynamic and heat transfer analysis of design concept. Experimentally demonstrate critical features at laboratory scale.

Phase II: Design, fabricate and test a brassboard fuel processing system to demonstrate and quantify the system benefits of the concept. The test unit should be sized and constructed to be compatible with a $\geq$ 10 kw fuel cell.

ARPA 93-052 TITLE: Medical Technology: Diagnostics, Intervention and Dynamic Health Assessment

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop and further exploit the defense technology and knowledge base in an effort to revolutionize the quality and delivery of health care and to reduce aggregate health care costs.

DESCRIPTION: Advances in key DoD technology-base areas (e.g. sensors, simulations, communications, information processing, and mathematical analysis) suggest a unique opportunity to significantly enhance the quality and delivery of health care to both U.S. combatants and the civilian population. Proposals are invited that would significantly improve capabilities in: (1) minimally invasive diagnostics, (2) point and remote care delivery, (3) training of physicians and combat medics, (4) dynamic health assessment (embedded outcomes analysis), and (5) resource allocation.

Phase I: Develop proposals which identify novel methodological and technological concepts and focus efforts on central research issues with reasonable proof of technical progress.

Phase II: Provide initial proof-of-concept demonstrations.

ARPA 93-053TITLE: Carbon Fiber/Polymer Matrix Pultruded Composite Structure

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Develop and demonstrate that pultrusion technology using carbon fiber and a polymer matrix can be cost effective in high-performance structural shapes for commercial and military aerospace applications.

DESCRIPTION: The major barrier to broader use of advanced composite materials is cost. Increased emphasis must be placed on low-cost manufacturing technologies. Pultrusion technology using fiberglass reinforcements is a well-developed cost-effective process in use in a variety of industrial applications and has shown potential for use in commercial and military aerospace applications. Additional effort is required to develop this technology and demonstrate its appropriateness for aerospace applications.

Phase I: Select two or more shapes that are suitable for commercial and military applications where pultrusion may offer significant cost savings. Develop a plan to extend the current technology by using carbon fiber as reinforcement and demonstrate the carbon fiber process in selected structural shapes. Input from an aerospace prime contractor will likely be beneficial in selecting the structural shapes.

Phase II: Perform required development work and demonstrate the technology and projected savings in full-scale structure on production equipment.

ARPA 93-054TITLE: Indium Phosphide Material for Microwave and Millimeter-Wave Monolithic Integrated Circuits

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Advance the development and fabrication of indium phosphide substrates and epitaxial material for microwave and millimeter-wave monolithic format devices and circuits. The material desired will lead to devices and circuits with performance characteristics superior to those fabricated from gallium arsenide.

DESCRIPTION: Gallium arsenide is the most common material that is suitable for use in developing microwave and millimeter-wave devices and monolithic format integrated circuits. However, superior performance characteristics have been achieved using indium phosphide as a substrate material, particularly at millimeter-wave frequencies. Nevertheless, indium phosphide material growth is at an embryonic stage of development and established sources of large-diameter (three-inch diameter or greater) indium phosphide wafers are not yet available. This project is directed toward the improvement of the characteristics of indium phosphide substrate material and substrate/epitaxial combinations that will result in devices and circuits with superior performance at microwave and millimeter-wave frequencies. It is expected that this project will also lead to the establishment of sources of supply for large-diameter (three-inch or greater) indium phosphide wafers with characteristics suitable for high-performance and low-cost microwave and millimeter-wave device and circuit development.

Phase I: Develop cost-effective techniques for producing indium phosphide substrate material and/or indium phosphide substrate/epitaxial material combinations that will result in material with characteristics suitable for yielding high-performance microwave and millimeter-wave devices and circuits. Perform initial growth runs to demonstrate the validity of the selected approach.

Phase II: Perform appropriate work to fabricate indium phosphide substrate material or substrate/epitaxial combinations with the characteristics described above. Focus upon material with three-inch or greater diameter. Employ approaches that will lead to the capabilities for producing large quantities of high-quality material at a low cost.

ARPA 93-055TITLE: Quasi-Optical Millimeter-Wave Circuits

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop quasi-optical millimeter-wave frequency circuits that have superior performance characteristics to conventional millimeter-wave monolithic integrated circuits.

DESCRIPTION: Quasi-optical components have been developed that have the potential for being produced at low cost and for providing promising performance at millimeter-wave frequencies. However, additional work must be performed to achieve higher power outputs and efficiency, to achieve greater levels of integration and to develop techniques and capabilities for low-cost production.

Phase I: Identify promising approaches for producing quasi-optical components such as millimeter-wave power sources, power amplifiers, mixers, low-noise amplifiers, or combinations of these circuits. Focus upon approaches that will result in batch fabrication capabilities leading to low-cost manufacturing. If possible, produce initial circuit samples and evaluate them for millimeter-wave performance characteristics.

Phase II: Continue development of quasi-optical millimeter-wave frequency circuits with emphasis on low-cost production. Evaluate yield and millimeter-wave performance of components that are produced.

ARPA 93-056TITLE: Modeling of Millimeter-Wave Monolithic Integrated Circuits

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Provide models for millimeter-wave monolithic integrated circuits, particularly those fabricated from indium phosphide. Emphasis should be placed on the development of models that accurately predict device/circuit performance from processing parameters.

DESCRIPTION: General - Millimeter-wave devices and integrated circuits fabricated from indium phosphide show excellent performance characteristics. However, in order to accurately and inexpensively develop more complex integrated circuits, accurate models are needed. This program focuses upon the development of these models with particular interest on models for high-power amplifier circuits fabricated from indium phosphide. Most desirable are models which can be used to relate processing parameters to circuit design parameters.

Phase I: Select one or more devices or integrated circuit configurations, preferably ones fabricated from indium phosphide, that operate at frequencies between 20 and 100 GHz. Develop models which result in accurate prediction of device and/or circuit performance. Provide a clear indication of accuracy and needed improvements for the model. Consideration should be given to how models proposed will extend Computer Aided Design (CAD) capabilities beyond those afforded by use of currently existing models and the compatibility of the models with existing commercially supported software packages and workstations.

Phase II: Complete model development and write appropriate software descriptions that can be used in conjunction with commercially supported software and workstations. It should be a goal to produce commercial software products for sale by an established microwave CAD vendor so that they can be used by the widest possible number of people.

ARPA 93-057TITLE: Biomedical Sensors

CATEGORY: 6.1 Basic Research

OBJECTIVE: Research and development of unobtrusive, portable biomedical sensors for vital-signs monitoring along with the associated signal processing and recording electronics.

DESCRIPTION: Defensive and offensive systems to ascertain the nature and extent of external threats (battle activity, chemical and biological agents, environmental conditions or infectious diseases) are numerous, while no systems exist to objectively determine the physical and psychological condition (fatigue, dehydration, nutrition, stress, illness or injury) of individual combatants or units. Biomedical sensors will bridge this gap and bring together elements of sensors and embedded electronics to develop unobtrusive biomedical sensors which will monitor, process, and report vital signs of mobile, active individuals. Future phases of the biomedical electronics program will incorporate the developed sensors with voice/video communication to field systems that would provide distributed medical aid. Such systems would move medical technology further towards the active area and use shared, visual environments to enable physicians at remote sites to supervise multiple medics closer to the casualties. By improving both the level and timeliness of medical attention, the treatment and survival rate of casualties will be improved. Existing biomedical sensor technology is driven by the needs of the civilian medical care industry which assumes passive/stationary individuals, invasive sensors, and ill or injured patients. The sensors envisioned under this program assume active/mobile individuals, unobtrusive sensors and healthy/uninjured individuals. Biomedical sensor research programs under current support are primarily disease-specific, invasive sensors. The sensors developed under this program would exploit new approaches and extend sensing technology to develop unobtrusive, wearable biomedical sensors that monitor vital signs of usually healthy individuals. Unobtrusive, wearable vital-sign sensors could be used in the civilian sector to improve emergency care delivery, allow for earlier discharge (reduced health care cost), and improve outpatient care.

Phase I: Explore and demonstrate new approaches (blood oxygen level monitoring via non-invasive blood-color sensing, processing of acoustic signals in arteries to determine blood pressure) that extend sensing technology to develop unobtrusive, wearable biomedical sensors that monitor vital signs of usually healthy individuals.

Phase II: Merger of independent, single biomedical sensors into a vital-signs monitoring suite of sensors. Integration of sensors with voice/video communications and recording modules. Field-testing and data collection from multiple individual sensor suites monitoring a collection of vital signs. Collation and analysis of normative data under a variety of physical and psychological tasks.

ARPA 93-058TITLE: Agile, Laminar Fabrication of Mixed-Material Structures

CATEGORY: 6.1 Basic Research

OBJECTIVE: Solve important electronics assembly and packaging problems by eliminating the assembly and packaging steps using laminar fabrication techniques.

DESCRIPTION: Assembly and packaging continue to present challenges in developing, fielding and commercializing new devices and systems. Different approaches, ranging from design for assembly to automated robotic assembly, have been offered as solutions to what is essentially a vestigial, manual assembly step. Along with the dramatic size reductions in microelectronic devices, there have been equally dramatic developments and refinements in microelectronic device fabrication. The electronics industry successfully solved the discrete component assembly problem by incorporating both the components and the interconnections (assembly) into the device fabrication process. The manufacturing features that are primarily responsible for enabling device and system complexity in microelectronics are: batch processing of multiple (millions) of components on the same substrate, assembled (connected) components as part of the fabrication process, mixed materials (e.g. ceramics, metals, polymers), common deposition/removal processes for the mixed materials (e.g. plasma etching, chemical vapor deposition), and sub-micron photolithographic feature definition and registration. Except for the photolithographic steps in the sequence, all other aspects of the microelectronic manufacturing process (batch processing, mixed material, common deposition/removal processes, feature definition/registration) can be applied to the fabrication of non-micro and non-electronic components and systems.

Phase I: Identify and demonstrate new materials, processes, and design methods for laminar manufacturing, including: advances in macro-scale, thick-film material deposition/removal techniques, conformal feature patterning, pattern-transfer schemes (mask generation and registration), maskless pattern transfer schemes, and the development of common processing techniques and equipment.

Phase II: Demonstrate prototype manufacturing cells capable of rapid, laminar fabrication of mixed-materials relevant to electronics packaging and assembly needs.

ARPA 93-059TITLE: Distributed, Unattended Sensor Networks

CATEGORY: 6.1 Basic Research

OBJECTIVE: Develop wide-area surveillance using distributed, unattended sensors communicating over wireless networks for use in: threat detection and monitoring, border control, environmental and agricultural applications, and process monitoring and control.

DESCRIPTION: Advances in low-energy signal processing and distributed microelectromechanical systems provide an opportunity for very-large-scale distributed systems where: (1) the sensing resolution and dynamic range are minimal and (2) the data rate to or from any particular sensor or device is quite low. Proposals are solicited for research in this area with emphasis placed on sensor network issues, including: wireless interrogation of distributed, low-power sensors; broadcast schemes and devices for the broadcast of power to distributed, normally-off sensors; and integrated, VLSI-process-compatible tuning elements and antennas. Investigations of such systems should be done in the context of high-leverage applications, such as unattended ground sensors or factory/process automation.

Phase I: Identify and demonstrate new low-energy, low-resolution, and low-dynamic range sensors, wireless transponders, or signal-processing techniques suitable for unattended, wide-area surveillance.

Phase II: Demonstrate fielded, wide-area surveillance networks in a prototypical application (unattended sensing or factory/process automation).

ARPA 93-060TITLE: Microactuator Arrays for Small-Area Displays

CATEGORY: 6.1 Basic Research

OBJECTIVE: Small-area, low-power visual, auditory and tactile displays in support of portable, embedded information systems for mobile, active individuals.

DESCRIPTION: Recognizing that MEMS (MicroElectroMechanical Systems) is as much a revolution in the fabrication of electromechanical devices as it is a revolution in the size of electromechanical devices, this area will explore new concepts in the integration of multiple devices to form small-area displays for visual, auditory (0.5 cm x 0.5 cm) or tactile (1 cm x 1 cm) information. Microdynamic displays will use high-density (> 10/square centimeter) microactuator arrays to achieve macroscopic action through the coordinated microscopic action of multiple, identical, and relatively simple microactuators. Common requirements for the construction of small-area, low-power displays using microdynamic systems require the development of high-yield, high-uniformity fabrication processes for microactuators; control strategies for inertia-negligible, friction/viscous force-dominated structures; and control of multiple (> 10,000) devices to achieve macroscopic function through coordinated microscopic action. Visual and tactile displays suitable for head-mounted applications and virtual reality/simulation platforms are of particular interest.

Phase I: Identify and demonstrate new concepts for small-area, low-energy, portable displays for visual, auditory and tactile information.

Phase II: Integrate visual, auditory or tactile display into a portable information display device or a head-mounted display platform.

ARPA 93-061TITLE: Develop Exercise Software to Run on ARPA JANUS-3D Wargame in UNIX Environment

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Develop example exercises to run on ARPA JANUS-3D for Army National Guard Forward Support Battalions. Further identify approach and level of effort for the development of software that contains all of the functionality for the Forward Support Battalion and its subordinate units.

DESCRIPTION: ARPA intends to demonstrate the functionality of using the JANUS Wargame enhanced with a "stealth" or "flying carpet" capability to train the headquarter's personnel (command and staff elements) of two National Guard Roundout/Roundup Brigades and their subordinate battalions. Each of these brigades includes a Forward Support Battalion which provides logistics, supply, medical and maintenance support to the brigade as well as to maneuver battalions engaged in warfare. Various versions of the JANUS Wargame have been developed and are currently fielded for conducting staff training in the Army, usually in an institutional or schoolhouse setting. These games are primarily designed to train maneuver unit commanders and staff during combat exercises, and thus the Combat Service Support (CSS) functions cannot be realistically practiced by the appropriate Forward Support Battalion personnel. Therefore, a critical part of the brigade does not get exercised or trained. Two recent developments permit JANUS to be used in a more widespread and productive way. First, JANUS is being converted to operate in the UNIX environment, which will enable the game to be affordably hosted on low-cost workstations and high-end personal computers. This new flexibility will make it economically feasible to distribute the necessary hardware to individual operational units. Second, ARPA has developed two versions of a "stealth" or "flying carpet" capability which permits an observer to inconspicuously and freely move around the three-dimensional virtual battlefield during battle and for After Action Review (AAR). Further study is required to determine the most effective training applications for this 3D capability.

Phase I: Develop exercise software for a limited number of critical combat functions which will enable an assessment of the utility of using JANUS-3D for training National Guard Forward Support Battalions, and the training value of the 3D capability. Phase I will produce a report that prioritizes tasks, determines methodology, and gauges the level of effort involved in fully developing JANUS for use in training Forward Support Battalions.

Phase II: Produce either (1) sufficient exercise software to bring the experimental system to full capability or (2) a significant enough portion of the software identified during Phase I to enable a test of the value-added properties of this approach. Phase II would likely be evaluated by an outside party, such as the Army research institute.

ARPA 93-062TITLE: Develop Low-Cost Reconfigurable Combat Vehicle Simulators for National Guard

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Develop portable simulators for use in National Guard armories or soldiers' homes that can be reconfigured to emulate various ground combat vehicles, have sufficient selective fidelity to train crew members and can operate on the Defense Simulation Internet (DSI).

DESCRIPTION: The National Guard training audience is widely dispersed in small groups throughout the United States. This dispersion makes the distribution of typical Army simulators too costly to be practical. The situation is further complicated by space limitations in community armories which cannot accommodate large simulator cabinets as well as by the diversity of units stationed at each armory. This project will produce a prototype of a land combat vehicle crew station that can be reconfigured to emulate other vehicles or crew stations and internet with other simulators via DSI. The simulator should have adequate selective fidelity to offer appropriate cues and responses to the crew member being trained. The initial prototype will demonstrate the key functionality (e.g., fire control and target engagement) of a crew station for two different ground vehicles (e.g., M1A1 tank commander station and M2/3 Bradley commander station) and the ability of the device to operate on DSI. For example, many of the gauges and button controls might be represented on interactive screens which could be easily reconfigured by the user (e.g., by selecting the positions and types of gauges using a mouse and menu). Analog controls (e.g., hand grips and pedals) might be selected and placed in a standard mount.

Phase I: Develop one crew station that is reconfigurable to represent two different ground combat vehicles and which operates on DSI. Produce a report that recommends the methodology and estimated effort required to produce two vehicles worth of crew stations and demonstrates full functionality of the two vehicles and their operation on DSI.

Phase II: Produce two full vehicles worth of reconfigurable crew compartments and demonstrate: the ability of the crew compartments to interact, the two vehicles' ability to interact via DSI, and the ability of the two vehicles to be reconfigured into another vehicle with full functionality for training purposes.

ARPA 93-063TITLE: Artificial Intelligence Mimic/Tutor

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Conduct a literature review and identify how to develop an artificial intelligence program that will identify adult students' idiosyncratic learning styles, organize the types of materials/information/media that compliment each student's preferred learning style, and prepare to coach/offer suggestions to students about learning options available to them.

DESCRIPTION: A review of past research suggests that students taught in a traditional classroom setting perform about two standard deviations below students taught the same subjects in one-on-one tutorials. However, this gap may be narrowed through the use of computer-based learning systems. The best computer-based interactive systems report an improvement over classroom performance of less than one standard deviation (about .8 to be precise). For instruction to be truly individualized, the student needs to be able to control the pace/tempo of instruction, the sequence that instructional/information units are presented, the content of the instructional units and the method used to present them (e.g., demonstration, text, interactive simulation). By the time students have reached adulthood, they have developed preferred ways of learning. Past computer interactive learning programs have permitted the student to control the pace of instruction and to proceed down alternative paths. However, these computer programs do not necessarily compliment the preferred learning styles of adult students. In fact, the term "learning style" has been defined using widely different variables. If a computer program could ascertain a student's preferred way of learning after several trials, then it would be possible for the computer to select and organize the learning materials on a particular topic to compliment the student's learning style. In fact, the program could go so far as to coach the student regarding how best to continue-- much like a tutor would. Artificial intelligence programs exist for indexing a wide variety of learning materials so that databases can be accessed and searched rapidly and the advent of high-speed computers and rapid-access high-volume databases can store and access a wide variety of learning material formats (e.g., audio, video, text, interactive simulations). Unfortunately, an artificial intelligence program that will mimic a student's search methodology and coach the student has not presented itself. This may be the key to closing the gap between tutorial and classroom student performance. Such a capability would make a significant contribution to training National Guard students in a distributed mode and retraining displaced workers. More significantly, such an interactive system could improve the quality of public education and impact the future development of educational materials and formats.

Phase I: Produce a literature review of learning styles and artificial intelligence program approaches that might solve the above-discussed problem. Prepare a separate report identifying how to develop such a program using military vocational training as the assumed test case.

Phase II: Develop a significant portion of the code in order to test the hypotheses proposed in Phase I. The instructional program(s) developed would be administered to adult military students and scientifically evaluated (probably by the Army Research Institute). Produce a report documenting the code and recommending how to further develop the program and instructional materials.

ARPA 93-064TITLE: Development of Interactive Computer-Based Training Programs for Home Use

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Identify innovative approaches for the development of interactive computer-based training programs for training National Guard soldiers at home. Target subjects include supply, maintenance, medical, and communications.

DESCRIPTION: National Guard soldiers are stationed in virtually every community throughout the United States. Since most of them have full-time jobs and are only part-time soldiers, they frequently cannot attend courses in residence at Army Training Centers. The use of computer-based instruction in the past has been hampered by the long time it takes to produce courses (e.g., CD/ROM), the cost of producing and distributing courseware, the cost of updating courseware, and difficulty in using courseware. Due to the dispersion of soldiers and the wide variety of training needed, this program seeks innovative ideas which would enable students to receive high-quality instruction at home. It is assumed that computer terminals or workstations could be assigned to students to take home for coursework (assumed cost <$5000 per suite). Breakthroughs in the use of central servers, new methods of producing CD/ROM, or other approaches are sought that will enable the conduct of vocational training that yields the same exit-level performance achieved by students who attend the instruction in residence and receive "hands-on" training experience. The following subject areas have been selected as representative classes of instruction: military supply, maintenance, medical, and communications.

Phase I: Produce a report that identifies innovative ways to deliver high quality vocational instruction in the home and recommended methodology and cost estimates for proceeding to develop a course of instruction selected by the sponsor in collaboration with the proposer during the course of Phase I development. For example, innovations may include new delivery media, breakthroughs in curriculum development that drive down development time and costs compared to current industry standards, new accessing capabilities, or an array of innovations not named.

Phase II: Develop at least one course in a subject area selected by the sponsor for evaluation with accompanying documentation. The instructional program would be scientifically evaluated (e.g., by the Army Research Institute). Include a report on methodology and recommended future action.

ARPA 93-065 TITLE: Low-Cost Techniques to Prevent Enemy Use of Captured Personal Communication Equipment

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop demonstration low-cost, soldier-friendly hardware which effectively prevents enemy exploitation of captured soldier-borne personal communication equipment, especially to obtain unauthorized access to current command and location information.

DESCRIPTION: In the future, each soldier may carry a personal communication and display system that transmits his position, messages, and the positions of his squad members and other nearby units. In addition to encryption (which will be government-furnished), it is essential that this information not fall into enemy hands via captured equipment or soldiers. Physical and electronic safeguards that ensure that secret data cannot be accessed and that the enemy cannot transmit misleading information via captured equipment are required. Devices such as body function sensors, periodic reactivation codes, voice recognition, or a combination of these or other techniques, are envisioned. These safeguards must not impede or place an undue stress or burden on the soldier.

Phase I: The objectives for Phase I are concept refinement, red-team (i.e., countermeasure) assessment, soldier integration analysis, cost estimation, and, to the extent possible, hardware demonstration.

Phase II: Extend the goals of Phase I and add development and demonstration of a complete system and components in both a laboratory and field environment.

ARPA 93-066   TITLE: Low-Cost, Add-On Guidance and Control Concepts for Artillery Projectiles or Rockets

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop and demonstrate low-cost, add-on guidance and control hardware which provides high terminal accuracy (<10 meters) for mortar, or rocket rounds in the current inventory.

DESCRIPTION: New navigation aids, such as the Global Positioning System, and new communications technologies, such as the cellular telephone, may enable simple but accurate guidance and control systems. If they are sufficiently low cost, these guidance and control systems could be cost effective when applied to current ordnance. Ideally, the device would be simple to install, such as by screwing into the fuze well of an otherwise unmodified round. Given these devices, a soldier on foot should be able to call for fire and be highly confident that the first round will land where he intends it to. This may require some form of designation by the soldier and/or in-flight communication with the round. The system should operate even when the soldier is in a dense jungle or an urban environment.

Phase I: The objectives for Phase I are concept refinement, system analysis, flight simulation, and cost estimation. Demonstration of critical components or technologies is desired.

Phase II: Extend the goals for Phase I and add development and demonstration of the guidance and control system. Flight demonstrations are desired, preferably with the ordnance attached. If this is not possible, convincing demonstrations of system capability must be performed.

ARPA 93-067   TITLE: Application of Thermoplastics for Lightweight Survivability

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Investigate the application of thermoplastics to produce an armor material with superior ballistic properties for light and/or ultra-light vehicles/aircraft.

DESCRIPTION: Current armor materials are primarily metals and ceramics. Because of their light weight, ceramics are the armor material of choice for lightweight applications. However, ceramics have limited multi-hit capability. Once a ceramic armor has sustained a hit, its ability to provide protection in that area is severely degraded. In addition, ceramics are considerably more expensive than metals. It is envisioned that thermoplastic materials with ballistic properties could be employed rather than ceramics to provide improved ballistic protection for lightweight applications at a reduced cost. Ideally, after ballistic impact, these materials would exhibit undegraded ballistic properties.

Phase I: Offeror will present theoretical and experimental verification of principle. Offeror will: (1) identify potential materials; (2) provide supporting rationale; and (3) demonstrate materials' ballistic properties.

Phase II: Offeror will demonstrate proof-of-principle. Employing the results of Phase I, offeror will develop and fabricate a quantity of his material to government specification for ballistic evaluation.

ARPA 93-068 TITLE: Self-Repairing Materials for Vehicle Survivability and Structural Applications

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Explore the potential for using self-repairing materials in ballistic applications and, secondarily, explore the load-bearing properties of these materials.

DESCRIPTION: Current armors are primarily made up of metals and ceramics. Unfortunately, both of these classes of materials are rendered useless upon impact. Therefore, in the event of a second ballistic impact in the same location, there will be no protection. In addition, the area surrounding an impact is weakened as well, which extends the area of vulnerability. Furthermore, ballistic impact degrades the structural properties of metals and ceramics are impractical for many purposes due to their limited load-bearing capability. In light of these limitations, it is envisioned that self-repairing materials with both structural and ballistic properties could be employed rather than ceramics or metals. Ideally, after ballistic impact, the restored materials would exhibit undegraded ballistic and structural properties.

Phase I: Offeror will present theoretical and experimental verification of principle. Offeror will: (1) identify potential materials; (2) provide supporting rationale; and (3) demonstrate materials' ballistic and load-bearing properties, if applicable.

Phase II: Offeror will demonstrate proof-of-principle. Employing the results of Phase I, offeror will develop and fabricate a quantity of his material to government specification for ballistic and structural evaluation.

ARPA 93-069 TITLE: Smart Materials and Active Structures in Light Combat Vehicles

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Apply subject technology to suppress vibration; assess damage; monitor structural and mechanical status and compensate for vibration, wear, aging and damage; monitor and control vehicle signatures such as thermal and acoustic.

DESCRIPTION: Traditional combat vehicles are primarily built of steel or aluminum and weigh up to about 60 tons. Examples are tanks, howitzers, and infantry fighting vehicles on personnel carriers. There is a need for a lighter, smaller vehicle capable of performing other combat missions such as reconnaissance. These light combat vehicles are expected to weigh between eight and 17 tons and to be built of advanced composite materials, including metals other than steel or aluminum. This approach to combat vehicle construction offers an opportunity to incorporate smart material and adaptive structure technology in a ground vehicle. Aircraft and naval vessels have already incorporated several aspects of this technology; however, technology used for ground vehicles must be highly robust and relatively inexpensive as compared to these other applications. By cleverly designing the hull, suspension, powertrain, crew compartment, and mission-specific equipment with smart materials and active structures in mind, it may be possible to achieve the objectives listed above. Sources of vibration are expected to include the suspension, powertrain, machine guns, wheels, and tracks. Structural and mechanical status reported by smart structures would include play in joints, rigidity, wear, fatigue, corrosion, change in strength/stiffness, temperature, vibration, stress, and strain. Sources of damage could include excessive loading on the structure; incoming ordnance such as artillery fragments, rifle or machine gun bullets, and land mines; fatigue; and corrosion caused by fuels and lubricants, toxic chemicals, salt, and humidity. Monitoring and control could be accomplished by the use of fiber-optic sensors imbedded in the composite structures, strain gauges, piezo-electric devices, shape-memory alloys, electro-rheological fluids, mass-tuned dampers, and electro-strictive devices, along with appropriate sensing and control algorithms.

Phase I: Offeror will present theory and experimental verification of principle. Offeror will clearly show application to a light combat vehicle environment. It is highly preferable that the offeror have brassboard or better hardware or working control algorithm that is readily adaptable for this utilization.

Phase II: Offeror will develop sensor and/or actuator hardware or control software to be used in a government demonstration of related technologies, integrated on a testbed vehicle. The purpose is to establish a benchmark state of the art for smart materials and adaptive structures in advanced composite, light combat vehicles.

ARPA 93-070 TITLE: Parametric Approach to Concept Exploration in Distributed Simulation

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Propose a software template for describing weapons systems in distributed simulation. The template should be sufficiently robust that a designer can adjust design parameters and performance characteristics to either represent existing systems or to perform sensitivity analyses on hypothetical future systems.

DESCRIPTION: Distributed simulation for training and development has evolved to the degree that new weapons system concepts are routinely simulated and evaluated on the virtual battlefield. However, the software architecture, while object-oriented, does not permit new system descriptions to be entered rapidly or easily. Given that many different complex systems can be broken into common logical groupings, e.g., propulsion source, control mechanism, weapon, sensors, etc., it seems logical to attempt to create a software template that can be modified to reflect the performance characteristics of any particular weapon system. This template could then be used to quickly explore the worth of new weapons concepts by entering the unique characteristics of the new system and then participating in distributed simulation exercises from a computer generated forces workstation. Sensitivity analyses could be rapidly conducted by evaluating different versions of the same system in common scenarios.

Phase I: Develop an object-oriented software template and demonstrate that it can be used to simulate an existing weapons system, the M1A1 tank, and a variation, the M1A2 tank, in a distributed simulation exercise performed from a computer-generated forces workstation.

Phase II: Enhance the flexibility of the software template to accommodate a wider variety of weapons platforms and demonstrate that it can be used to simulate both land vehicles and aircraft in a distributed simulation exercise by participating from a computer-generated forces workstation.

ARPA 93-071 TITLE: Innovative Approaches to Linking Wargames

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Propose methods for linking existing military wargame simulations and the evolving man-in-the-loop distributed simulation capability based on SIMNET (SIMulation NETworking), thereby permitting exchange of data and interoperability.

DESCRIPTION: Distributed simulation for training and development has evolved to the degree that new weapons system concepts are routinely simulated and evaluated on the virtual battlefield. This man-in-the-loop capability injects the human element into the simulation and permits a more realistic assessment of the simulation results. However, because this approach to simulation takes place in real time, it is difficult to generate data in sufficient amounts to permit statistical inference about the battlefield effects of a new system or a change in tactics - that is, it is both too time consuming and too costly. To overcome this obstacle, many analysts use wargaming models that can run faster than real time to generate the data required, or they use computer-generated forces within distributed simulation to reduce the cost of manpower. The ability to combine the strengths of distributed simulation with those of analytical wargames through interoperability would create significant opportunity for improved effectiveness analysis at reduced cost.

Phase I: Develop an approach to linking wargames with distributed interactive simulations in a manner that permits seamless transfer of information and interoperability.

Phase II: Implement the approach developed in Phase I and demonstrate the ability to pass information between an existing wargame and a SIMNET-like exercise at an isolated simulation node.

ARPA 93-072 TITLE: High-Speed Electrodes for High-Density Optical Guided Wave Devices

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Develop high-speed electrode structures suitable for Electro-Optical (EO) devices on guided wave substrates which have high packing density and cause minimal degradation to device performance.

DESCRIPTION: High-speed, linear guided EO devices have been demonstrated using traveling wave electrode structures operating in the 10-25 GHz range using EO materials such as LiNb03. However, these devices generally consist of only one or a small number of devices per substrate. Before it will be possible to increase the packing density, issues such as electrical and optical isolation, as well as interconnects, must be considered. This may include the development of new optical structures in support of improved device electrodes.

Phase I: Design and develop optical and electrode structures for multiple-element devices that optimize performance and isolation at frequencies in the range of 1-30 GHz. Determine performance limitations and trade-offs. Perform a device demonstration for design verification.

Phase II: Develop and demonstrate high-density device designs for specialized EO components. Optimize designs for performance trade-offs and comparisons.

ARPA 93-073 TITLE: Multisensor Inspection for Microelectronics

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop techniques for sensor fusion between multiple inspection methods for use with subminiature electronic assemblies.

DESCRIPTION: A number of inspection techniques exist for inspecting electronic assemblies such as printed wiring boards and multi-chip modules. These techniques include x-ray, infrared, ultrasonic, and three-dimensional x-ray. Often, there is a trade-off between equipment sensitivity and reliability of finding defects: higher sensitivities find more defects but cause more false alarms. A system architecture and algorithmic approach is needed that will fuse image data from multiple inspection methods and, in essence, will increase the signal-to-noise ratio in the data. Such a technique would increase the probability of finding defects, reduce the incidence of false alarms, and possibly allow for discrimination between various defect types. Real-time image processing, neural networks, fuzzy logic, and rule-based systems, or a combination of these, should be considered.

Phase I: Requires concept exploration, review of current literature, feasibility study, and development of proposed system architecture/algorithms. Development of a System Concept Document (SCD), which must include a consideration of necessary hardware, multi-system inspection data fusion techniques, programming strategy, and applicable statistical analysis.

Phase II: Requires preparation of detailed design drawings, collection of data from proposed individual inspection systems, development of pseudo-code to implement algorithms, and assembly of a prototype system. Prototype design will be verified by inspecting example electronic assemblies.

Phase III: A commercial "factory-hardened" system would be designed and manufactured with potentially very broad applications in electronics manufacturing for aerospace, communications, and weapons, as well as numerous consumer products.

ARPA 93-074 TITLE: Residue Number-Based Fast Fourier Transformers (FFTs)

CATEGORY: 6.1 Basic Research

OBJECTIVE: Establish the requirements for Residue Number Systems (RNSs) arithmetic with the ultimate goal of implementing the FFT algorithm in hardware in Phase II.

DESCRIPTION: FFTs are used extensively in radar processing. FFTs implemented with floating-point arithmetic yield the best computational accuracy at the expense of operating speed; whereas fixed-point arithmetic implementations provide for higher processing rates, but with a loss in accuracy. RNSs which utilize parallel processing paths could yield FFT implementations with advantages in speed and accuracy. However, in order to realize the advantages of the RNSs, advancements need to be achieved in the hardware computation of residue-based arithmetic operations, particularly multiplication. RNS-based techniques that obey the cyclic convolution property, such as number theoretic transforms, should be considered in development of the RNS hardware. Further, the designs should be developed for state-of-the-art processor technologies, such as transputers and digital signal-processor chips. Development of special-purpose integrated circuit chips, for example, ASIC, should only be considered if shown to be cost effective.

Phase I: Requirements for RNS arithmetic operations must be established. The FFT algorithm to be implemented shall be considered when developing these requirements. Concepts and preliminary designs will be developed. As appropriate, designs will be analyzed to compute expected performance improvements.

Phase II: The designs developed under Phase I will be completed, implemented, and tested. A prototype FFT, utilizing the improved RNS arithmetic operations, will be fabricated and evaluated. The evaluation should determine speed and accuracy for comparison to current FFT processors.

ARPA 93-075 TITLE: Parallel Infrared (IR) Magneto Mapper for Semiconductor Material

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Demonstrate simultaneous measurement of IR detector material properties over a wafer or film area using Faraday rotation.

DESCRIPTION: Faraday rotation has been demonstrated as a non-contact testing technique for characterizing the electronic properties of semiconductor material to improve the yields of IR detectors. It is a replacement for the Hall technique which requires contacts on the sample and is incapable of high resolution. Present Faraday rotation mapping technology requires serial sampling of the material area. It is desirable to make Faraday rotation measurements simultaneously over the wafer in order to rapidly screen material to be used in detector design.

Phase I: Identify approaches for parallel measurement of Faraday rotation in IR detector material and develop a magneto-optical mapper design. Perform laboratory demonstrations to prove the feasibility of the design.

Phase II: Construct and test a proof-of-principle demonstrator.

ARPA 93-076 TITLE: Optical to Electrical Power Conversion Unit

CATEGORY: 6.1 Basic Research

OBJECTIVE: Develop a reliable and efficient laser to electrical power conversion unit to power telemetry during the ground testing of missiles in strong electromagnetic environments.

DESCRIPTION: Currently, batteries are used to power missiles and missile telemetry during electromagnetic effects testing of these missiles. The batteries used have to be replaced often during testing, a procedure which requires the missile to be disassembled, batteries replaced, and the missile reassembled. This procedure is time consuming and disturbs the test environment, causing errors in the test result. This power cannot be delivered to the missile by wires because the connecting wires would couple the electromagnetic radiation into the missile, disrupting the electromagnetic profile of the missile under test. A solution to this power delivery problem is to send laser power via a nonconductive fiber optic into a module located inside the missile. The module will contain photovoltaic cells which will convert the laser power into electricity. This approach is challenging because significant powers, 28 volts dc and 0.5 amps, are required within the compact space of a two inch by two inch cylinder. A second requirement is 5 volts and 0.5 amps within a one inch by one inch cylinder. This technology will ease electromagnetic disturbance during testing of missiles and missile systems and lead to missiles hardened against electromagnetic interference.

Phase I: Design and build two prototype power conversion modules that demonstrate the capability of producing the 5 volts dc at 0.5 amps and the 28 volts dc at 0.5 amps within the compact space requirements. Assume the optical input to be gallium arsenide diode laser power at a wavelength of 810 nm delivered via a 400 ìm glass fiber optic. Phase II: Refine the designs of Phase I and deliver five each of the 2.5 watt and the 14 watt modules. These units must supply power regulated to within 0.1% of the nominal voltage. These units should be optimized to yield a maximum power conversion efficiency.

ARPA 93-077 TITLE: Payout Dynamics Experimental Investigation

CATEGORY: 6.1 Basic Research

OBJECTIVE: Advance high-speed payout reliability technology. Develop test matrices, test hardware, and data reduction techniques.

DESCRIPTION: Fiber-optic cables are now providing communication links for many tethered vehicle and weapon systems. The demands for increased range, speed, environmental fortitude, and shelf life continue to increase. Thus, added emphasis has been placed on defining the communication link's reliability. The probability of reliability and the design limitations of fiber-optic dispensers are not easily predicted. The dynamics of fiber payout have not been adequately defined. Laboratory data has shown that non-steady state conditions occur during fiber payout at high speeds. Several parameters contribute to the phenomena observed during payout; however, the acceptable range of the parameters or the limits of a dispenser design is unknown. In order to learn the conditions under which reliability degrades, tests must be conducted that explore the range boundaries of payout parameters. A test matrix must be devised that will test system limitations, hardware must be assembled that can collect the proper data, and the tests must be conducted under stringently monitored conditions.

Phase I: Review Government developed optical-fiber payout test matrices. Determine or develop a test matrix that incorporates parameters as necessary. Develop a test plan and procedure. Identify test data collection and data reduction equipment. Conduct feasibility test to verify test setup. NOTE: Well-equipped, high-speed payout facilities are available at U.S. Army Missile Command (MICOM), Redstone Arsenal, AL.

Phase II: Design and fabricate fiber-optic dispensers for design of experiments testing. Define test values for bobbin diameter, length, and taper angle; payout velocity; adhesive strength; fiber type and diameter; and temperature, at a minimum. Conduct payout testing, data collection, and data reduction for determination of the influence rating of parameters. Based on test-data interpretation, predict the probability of reliability curves for optical-fiber payout.

ARPA 93-078 TITLE: Compact Acoustic Plane Wave Generator

CATEGORY: 6.2 Exploratory Development.

OBJECTIVE: Design and develop a small-scale acoustic plane wave generator for acoustic frequencies between 60 Hz and five KHz.

DESCRIPTION: A device is required for the generation of planar acoustic waves over a symmetrically dimensioned volume of approximately one cubic meter in the frequency range 60 Hz to five KHz. Frequency response over the operational frequency band should be reasonably flat. The generation system should be designed to occupy an enclosure suitable for location in a modest-size laboratory. The system is to be fed from one end of the enclosure with 16-bit digital acoustic data from which the analog acoustic signals must be produced and transmitted within the enclosure. Test article access ports are required at the opposite end of the enclosure. An acoustic probe system within the enclosure is required for test and calibration of the generation system.

Phase I: Design, development, and verification by means of a digital simulation.

Phase II: Fabrication and demonstration of the generation system.

ARPA 93-079 TITLE: Thrust Vector Control (TVC) System for Low-Cost Expendable Turbojet Engines

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop a flight-vehicle control system for a tactical missile that solely utilizes thrust vector control of a
turbojet sustainer propulsion system.

DESCRIPTION: In the design of future missile systems, an increased emphasis has been placed on reducing the radar cross-section of the airframe. A significant contributor to the overall radar signature of a tactical missile are the control surfaces. Elimination of control surfaces should, in general, greatly reduce the radar cross-section of the missile. One means of eliminating the control surfaces on a turbojet powered tactical missile is to employ a TVC system that utilizes the turbojet exhaust to provide flight vehicle control authority. Consequently, the development of such a turbojet sustainer-based TVC system for a tactical missile is necessary. The TVC system to be developed should be designed for integration and operation with an existing, small, low-cost, expendable turbojet engine. The system should be consistent with incorporation in a tactical missile and emphasis placed on minimizing cost, weight, and parts count. An integrated system should function simultaneously as both the sustainer propulsion system and the flight vehicle control system. An integrated control system should provide for control of both the thrust magnitude (engine fuel control) and the thrust direction (TVC). A fluidics-based control system should be evaluated. The integrated sustainer/TVC system should provide pitch, roll, yaw, and velocity control at magnitudes and rates that are consistent with those required by a subsonic tactical missile.

Phase I: Design, fabrication, and delivery of a heavy-wall TVC system for integration with a Government furnished small turbojet engine. The following engines are available: Sunstrand TJ-50; Williams WJ119, P8910, P9005; Teledyne 305-10; Allison 120; and Technical Directions four inch and seven inch.

Phase II: Design, development, and delivery of a flight-weight integrated TVC system. The system shall be integrated with a turbojet propulsion system and delivered to the Government for experimental evaluation.

ARPA 93-080 TITLE: High-Strength Bend-Insensitive Polarization Maintaining (PM) Fiber Development for Inertial Sensor Applications

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Advance the development and fabrication of PM fibers that are stronger and insensitive to bend losses, and thus are highly reliable inertial sensors.

DESCRIPTION: PM optical fibers that are currently being produced show a degraded extinction ratio due to bend losses. In inertial sensors this means that sensors cannot be packaged as compactly as is theoretically possible. In addition, the PM fibers are not very strong and, therefore, tend to break during handling or fail over time. PM fibers used for inertial sensor applications should be more reliable and suitable for harsh environments.

Phase I: Develop an approach for fabricating PM fibers with greater strength and less bend sensitivity, while maintaining current PM fiber performance standards.

Phase II: Fabricate prototype optical fiber and evaluate the performance characteristics of the fiber. Provide a detailed set of procedures, including a description of the equipment and facilities necessary to produce the high-strength, bend-insensitive optical fiber in large quantities.

ARPA 93-081 TITLE: Micro-Lasers for Infrared Scene Projection

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Develop micro-laser technologies for future application to Infrared (IR) scene projection in Hardware-in-the-Loop (HWIL) simulations.

DESCRIPTION: Several weapon systems are currently under development throughout all branches of DoD which utilize multiple IR wavebands for target detection and intercept. Both two-dimensional focal plane arrays and linear arrays of detectors with less than 30 total detectors are used in these systems. In the scanning systems, optical components scan the total field of view and the detector elements are read out at extremely high rates. Conventional IR projection techniques cannot support the modulation of the IR signal outputs at the rate required for accurate HWIL tests of these systems. These performance limitations have forced the exclusion of the IR detectors from HWIL simulations. HWIL simulations are necessary to adequately assess weapon-system performance, therefore, innovative and fast IR projection techniques are needed to overcome these limitations. Currently, two-dimensional micro-lasers are being researched for application in the visible to near-IR region. Accordingly, if extensions can be made into the longer wavelengths, an IR projector capable of supporting HWIL tests could be developed.

Phase I: A conceptual design and laboratory demonstration of two-dimensional micro-laser devices operational at the MWIR or LWIR wavelengths.

Phase II: Extension and upgrade of this technology for use in HWIL simulations of IR missile systems.

ARPA 93-082 TITLE: Automated Bobbin-Baselayer Inspection System

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop a nondestructive automated system (methodology, software, and equipment) capable of characterizing the geometry of the baselayer and wound-fiber layers and that can be used as an evaluation tool for these parameters.

DESCRIPTION: Fiber-Optic Guided Vehicle (FOG-V) dispensers designed for high-speed payout consist of a bobbin, which is precision wound with the optical-fiber data link. The baselayer is on the surface of the bobbin and forms the winding guide for the first layer of optical fiber. Anomalies, such as uneven groove spacing, bicuspid grooves, uneven groove depth, etc., can occur in fabrication of the baselayer. At present, there are no dedicated tools that can be used to evaluate the integrity of the baselayer or to identify and characterize significant flaws in the baselayer. The required system resolution is +/- 0.5 micrometer (+/- 0.00002 inch) in the radial direction and the ability to measure distance between the baselayer centers within +/- 20 micrometers from the flange end and within +/- 2 micrometers between adjacent baselayer grooves. The developed system must be capable of recording the change in radius of the fiber-optic dispenser surface along the bobbin axis and at points around the bobbin circumference. An automated system is needed so that no operator intervention is required after setup. The tool should be flexible enough for use in correlation of winding flaws to baselayer anomalies, and to determine acceptance criteria for the baselayer. An existing system which resides at U.S. Army Missile Command (MICOM), but does not have the resolution or speed necessary to meet the above requirements, can be made available for modification.

Phase I: Evaluate the MICOM GFE Slump Measuring System for use as an automated inspection system for the bobbin/baselayer. Demonstrate a breadboard automated baselayer measurement system by inspecting at least two bobbins (one aluminum IOE FOG-M design and one fiber glass filament wound composite) before and after baselayer application and winding.

Phase II: Complete development of the system. Perform studies to correlate baselayer anomalies to fiber-winding flaws. Determine acceptance criteria for baselayers. Perform acceptance measurements for 20 bobbin baselayers.

ARPA 93-083TITLE: Models for the Growth and Processing of Infrared (IR) Materials

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop models for simulation of infrared material growth and detector manufacturing.

DESCRIPTION: The growth and processing of IR material and devices require extensive knowledge of material parameters over a wide range of processing conditions. This is especially important in a flexible manufacturing environment, where equipment and processes must adapt rapidly and precisely to material with varying characteristics and devices over a wide range of operating conditions. Models, with the capability to simulate major aspects of the IR manufacturing process, including the equipment environment, are necessary to establish the robust manufacturing processes necessary for IR material and detectors. Examples of the models required include a description of the growth of bulk cadmium telluride crystals, the generation and propagation of defects in bulk and epitaxial layers, and models of the detector surface properties, doping and junction formation mechanisms. These models must be experimentally verified and applied to process-control systems for IR material and device manufacturing.

Phase I: A specific element of IR material growth or detector manufacturing must be selected and a strategy developed to establish a simulation, taking advantage of prior theoretical and experimental work. The physical mechanisms controlling the process must be investigated and analytical expressions and algorithms developed to predict material properties under a wide range of operating conditions. A strategy must also be developed to experimentally validate the model. Computer code will then be written to describe a representative segment of the model, and the model exercised to determine the agreement with published data. The interface of the model with processing equipment must also be considered and a strategy developed with equipment vendors and IR manufacturers to utilize the model in manufacturing.

Phase II: The complete analytical model of the IR process selected must be coded, exercised and compared with experimental data. Graphical simulations of the manufacturing process should be utilized wherever possible. The simulation must include the capabilities to predict characteristics over large areas wafers, to provide insight into techniques to reduce defects in IR materials and devices, and to produce high-density, multi-layer devices. The model developed must be integrated with equipment for the processing and characterization of IR material and devices.

ARPA 93-084 TITLE: Process Control Technology for Infrared (IR) Materials Growth and Device Fabrication

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop sensors to monitor IR material and detector characteristics during manufacturing. The sensors are to be integrated into a process control architecture and used in IR material and device manufacturing.

DESCRIPTION: Precise control of processes for the growth of IR material and the fabrication of IR detectors is essential to achieve high yields and low costs in the relatively low-volume arena of semiconductor technology; an area which is critical to defense systems. A major factor in development of a process control technology for IR material and devices is the establishment of a suite of sensors which can be integrated into manufacturing equipment and used as real-time process monitors. Examples of IR manufacturing processes which necessitate these sensors include: bulk and epitaxial growth of substrates and IR sensitive layers, surface processing, junction formation, etching, and doping control. The sensors must characterize the optical, electrical, or structural properties of the material during processing, without disturbing the IR material or the manufacturing process. Several of the characterization techniques used in the laboratory to evaluate IR materials are potentially applicable to this project.

Phase I: A sensor or suite of sensors must be selected to monitor a particular aspect of the IR material growth or device processing. A strategy for measuring critical process parameters must be developed, including the establishment of a relationship between the sensor output and a particular aspect of the IR manufacturing process. Measurements must be made in the laboratory to verify the accuracy and repeatability of the sensor characteristic. A specification for the sensor must be developed and a plan established for interfacing the sensor into a control architecture to be used in IR material growth or detector manufacturing equipment.

Phase II: The sensor(s) must be integrated into a process control system and demonstrated on a specific aspect of the IR manufacturing process. The impact of the process control system on the yield of the manufacturing process must be established experimentally. An interface with an IR material growth or detector manufacturer is also necessary for transition of the control technology into the manufacturing environment.

ARPA 93-085TITLE: Processes and Equipment for Advanced Devices

CATEGORY: 6.1 Basic Research

OBJECTIVE: Develop enhanced semiconductor manufacturing processes and equipment which enable abrupt, retrograde and shallow junction formation with low thermal budget.

DESCRIPTION: The fabrication of Ultra-Large-Scale Integrated Circuits (ULSIC) has relied upon conventional ion implantation and hot-wall furnace annealing technology for the formation of device junctions and isolation wells. As device geometries and operating voltages decrease, innovative processes and manufacturing equipment will be needed for the formation of ultra-shallow (<50 nm) junctions and deep, abrupt or retrograde wells. The resulting junctions must exhibit abrupt impurity profiles, low sheet resistance, and no substrate damage. Retrograde profiles must demonstrate at least an order of magnitude increase in concentration from the surface to the junction over a distance of several hundred nanometers. All of these processes must be implemented with low thermal budget to minimize dopant redistribution. This program will develop alternatives to conventional ion implantation, novel processes for dopant activation and associated processes to achieve advanced junctions profiles. Candidate technologies of interest include, but are not limited to: adsorption/annealing with Rapid Thermal Processing (RTP), low-energy dopant deposition, plasma dopant incorporation, gas immersion laser doping, low-energy implantation for shallow junctions and high-energy implantation for deep retrograde profiles and associated equipment for process control. Proposed processes and equipment must be fully compatible with cluster tool environments, exhibit the potential for manufacturing throughput and must be compatible with conventional integrated circuit device fabrication sequences.

Phase I: Demonstrate initial feasibility of the proposed process or equipment, provide initial yield and manufacturing costs estimates and develop a commercialization plan.

Phase II: Demonstrate a prototype process (or subprocess) in a manufacturing capable tool using the results of Phase I.

ARPA 93-086 TITLE: Simulation Tools for Plasma Reactor Synthesis

CATEGORY: 6.1 Basic Research

OBJECTIVE: Develop a set of simulation tools for the synthesis of plasma reactors for the semiconductor manufacturing industry.

DESCRIPTION: Plasma processing has become an enabling technology for manufacturing integrated circuits with decreasing feature sizes and aggressive topologies. These reactors operate over a wide variety of pressures and with a broad range of reaction constituents to achieve the selected manufacturing result. To date, these process tools have been designed through successive trial and iteration rather than by a model-based approach. As semiconductor manufacturing drives to increase process uniformity and reduce wafer-level defects, a new method of designing plasma tools will be needed. This two-phase program addresses the development and implementation of model-based simulators for the synthesis of reactor chambers, associated gas distribution systems, and process sensors for plasma reactors used in the semiconductor manufacturing industry. The resulting models must accurately describe the process and must be computationally efficient.

Phase I: Identify and develop initial models which address, but are not limited to, process kinetics, gas flow dynamics, particle nucleation, plasma-induced device damage, surface charging, and particle transport.

Phase II: Refine and validate these models for a candidate manufacturing process used in the semiconductor industry and demonstrate the use of these models to synthesize a new or improve an existing plasma reactor or subsystem.

ARPA 93-087 TITLE: Chemical Vapor Deposition (CVD) of Next Generation High-Density Interconnects

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop CVD processes and equipment which interface with cluster semiconductor manufacturing tools for sub-0.25 micron geometries.

DESCRIPTION: Advanced CVD of dielectrics and metals are key to achieving the device performance and integration levels of the next decade. As interconnect dimensions are reduced, clock distribution and cross-talk become limiting factors in high-speed, high-integration designs. A variety of device interconnect strategies have been proposed in literature addressing these effects. This program will identify and develop innovative CVD processes and equipment for high-speed, high-integration circuits. Processes of interest include CVD copper for plug and interconnect, refractory barriers, selective metal deposition, low dielectric constant films (< 1.5), planarized films, low-temperature CVD deposited films (< 300C), low defect-density films (0.004 defects per square centimeter), and improved uniformity (3%). The resulting processes will be demonstrated in a cluster tool for implementation into a semiconductor manufacturing flow.

Phase I: The initial program phase will identify CVD process improvements and propose a cluster tool implementation approach. The recommended approach will be evaluated for projected performance limitations, process and tool integration, throughput limitations and impact on device yield.

Phase II: The final program phase will optimize the process improvement and result in the demonstration in a prototype cluster tool for integration in a manufacturing environment.

ARPA 93-088TITLE: Lenses and Mirror Technology for X-ray Lithography

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Develop technology related to optical elements for use in proximity (one nm) or soft x-ray (13 nm) projection lithography. Technologies of interest include fabrication techniques, materials, metrology, characterization, and application of these optical elements.

DESCRIPTION: Current approaches to x-ray lithography include proximity and projection methods, using wavelengths in the range of one and 13 nanometers, respectively. The availability of a wider variety of appropriate optical elements will provide the lithography tool designer with flexibility to optimize tool design. In recent years, several approaches have demonstrated the capability to further control x-ray beams and enhance the performance of x-ray lithography tools. Opportunities for improvement in performance of these optical elements exist in the areas of sources, materials and fabrication methods, controls used during fabrication, alignment and positioning in the optical path, and characterization of the finished product. Finally, the success of the efforts will be indicated by the installation and characterization under testbed conditions.

Phase I: Identify an approach which offers improvements such as cited above, evaluate the technology base against needs, and detail a plan to develop and demonstrate a prototype.

Phase II: Build and characterize a prototype and detail a plan to integrate into a lithography tool.

ARPA 93-089TITLE: Stress-Free Membranes for Submicron Stencil Mask

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Explore the theory and materials systems that would facilitate the fabrication of stencil masks for 0.18 micron and smaller design-rule lithography.

DESCRIPTION: Both ion-beam and electron-beam projection lithography can be implemented with the use of stencil masks. These lithography schemes are being considered as alternatives for optical or x-ray lithography when the design-rule scaling in semiconductor Integrated Circuits (ICs) reaches dimensions of 0.18 micron or smaller. At that time, it is also expected that an ICs chip field size will be 20 by 20 mm or greater. Technology is being sought that can be used to fabricate stencil masks appropriate to these lithography goals. Initial effort should concentrate on identifying the appropriate stencil mask material or materials and suitable fabrication technology. The theoretical effort must address stress issues, trade-offs between one-to-one masks and reduction masks, temperature limits, and other pertinent problems.

Phase I: Select the material(s) and processing techniques that result in the most promising stencil masks. Provide theoretical justification for the choices and tabulate pertinent theoretically derived performance characteristics.

Phase II: Fabricate proof-of-concept, high-density stencil masks for 200mm wafers. Establish experimental performance characteristics and cost of fabrication for such masks.

ARPA 93-090TITLE: Photoconductive Switch for Reconfigurable Antenna

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop high-performance photoconductive switches for interconnecting antenna segments so that the antenna can be optimally shaped for a specific function.

DESCRIPTION: An optimally shaped antenna is desireable for specific functions. An optically controlled reconfigurable antenna can serve to combine many different antennas into one. Photoconductive switches actuated by photons provide connectivity with desireable electrical characteristics. The switches must be integrable into the antenna pattern. The choice of material system, and the device design and processing are critical steps leading to the successful development of this technology.

Phase I: Propose and verify optimal device design. Demonstrate discrete devices with desired characteristics. Outline approach to realize an integrated antenna with photoconductive switches.

Phase II: The performance of the proposed antenna system will be simulated. The antenna system will be fabricated and tested in various configurations. Optimal performance criteria will be delineated while minimizing optical control power. Reiterate process to generate field testable components. Demonstrate and deliver to system applications companies for incorporation.

ARPA 93-091TITLE: Simulation, Modeling and Computer Aided Design Tools for Optoelectronics Components

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Design and develop new optoelectronic devices and integrated circuits through optimization of computer simulation and modeling of semiconductor materials and device structures for applications in high-speed signal processing and computation.

DESCRIPTION: Combining optical and electron devices into optoelectronic systems has emerged as the method of choice for enhancing the speed performance of signal processing, computation, and telecommunications. Significant advantages in speed, power, weight, and size appear if monolithic integration is achieved between the electron and optic devices on a single semiconductor substrate. Different materials properties for the separate electronic and optical devices makes it difficult to design and optimize the performance of the devices and circuits. Computer simulation methods have emerged as a critical element in the process of designing electronic devices and circuits. Numerical simulations need to be developed for optical devices such as lasers, modulators, wave guides, and detectors for design and optimization of optoelectronic integrated circuits. Such simulation and modeling will greatly reduce the development costs and assist designers in optimizing circuit designs.

Phase I: Numerical simulation methodologies will be chosen and developed for computer modeling of integrated semiconductor optoelectronic devices and circuits. Physics and circuit performance should be addressed and optimized with respect to threshold current, output power, efficiency, and modulation frequency.

Phase II: The procedures developed in Phase I will be extended to consideration of devices in which small dimensions leading to quantum effects are dominant. These results will be validated by coordination with experimental programs at commercial, university, and government laboratories. Designs will be proposed that lead to the highest speed circuits of interest to telecommunications, computation and signal processing.

ARPA 93-092 TITLE: Applications Demonstration Utilizing Optical Computing

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Demonstrate specific applications using optical computing.

DESCRIPTION: Optical computing is capable of massively parallel processing and may generate a new computing paradigm. At this point, the clear advantages intrinsic to optical computing have not been isolated. This solicitation seeks to clarify the potential usefulness of this new technology by demonstrating applications that delineate the advantages of optical over conventional computing.

Phase I: Select and nominate applications that require unique functionalities provided by optical computing. Discuss the layout and component requirements for this demonstration. Delineate the advantage accrued by using optical computing technology. Compare, in detail, performance differences between electronic and photonics as applied to the specific application through simulation.

Phase II: Fabricate and assemble the proposed optical computing system. Generate control hardware and software, input/output requirements to fully demonstrate the selected applications. Analyze the advantages and the disadvantages of optical computing from the data accumulated while running the experimental application. Modify the system to obtain optimal results and compare with the results using conventional approaches.

ARPA 93-093 TITLE: Lightweight, Hand-Held Gamma Ray Detector with Isotope Identification Readout

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Investigate and develop the hardware and software for a small gamma ray detector to identify the isotope(s) emitting gamma rays.

DESCRIPTION: Nuclear nonproliferation has attracted a considerable amount of world-wide interest. In order to monitor the suspected movement of radioactive materials from one location to another, radiation detectors with increased versatility are needed. Present detectors are large and have sufficient resolution to display gamma peaks, but do not include an automated system for isotope identification. The detector envisioned would be about the size of a hand-held, videocassette recorder remote control and have a display identifying the radioactive isotope(s) emitting the gamma rays. This beginning system should possess a resolution of less than five percent (5%) and a count time of less than one minute. At the end of the count time, the display should provide a readout identifying the isotope(s) of interest.

Phase I: Investigate, identify, develop, and select the materials and software needed to produce a lightweight, hand-held gamma ray detector. Hardware and software capable of using the information gathered by the detector should be evaluated for ruggedness, size, weight, and speed in identifying the isotope of interest.

Phase II: Develop and demonstrate a prototype gamma ray detector.

ARPA 93-094 TITLE: Gamma Ray Lens Feasibility Study

CATEGORY: 6.1 Basic Research

OBJECTIVE: Provide a feasibility study discussing the development and potential applications of a gamma ray lens.

DESCRIPTION: A number of years ago, the possibility of using a neutron lens for neutron activation analysis seemed remote; however, this is no longer the case. Smooth, hollow-glass capillaries are now used to guide neutrons and x-rays by way of multiple reflections along the capillaries' inner walls. The June 4, 1992 publication of *"Nature"* described a neutron lens developed in Russia. As an extension to this concept of focusing particles or high frequencies of the electromagnetic spectrum, a feasibility study should be conducted that explores the practicality and usefulness of focusing gamma rays. This study should investigate the feasibility of materials, their size and shape, and the cost of producing such a lens. Possible applications of this lens should be noted as well.

One possible use of a gamma ray lens device would be to focus photons on cancerous tissue directly. Other applications beyond medicine should also be considered.

Phase I: Perform analysis of the feasibility of focusing gamma rays using a mechanical lens device.

Phase II: Investigate materials, size and shape, and cost of a mechanical device needed to focus gamma rays on a sample material.

ARPA 93-095 TITLE: Lightweight, Hand-Held Chemical Detector with Chemical Identification Readout

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Investigate and develop the hardware and software for a small chemical detector to identify the effluent of interest.

DESCRIPTION: Nonproliferation of weapons of mass destruction has attracted a considerable amount of world-wide interest. In order to monitor the suspected production of chemical weapons, chemical detectors with increased versatility are needed. Present detectors do not include an automated system for chemical identification. The detector envisioned would be about the size of a hand-held, videocassette recorder remote control and have a display identifying the number of chemical effluents in the area. The display should provide a readout identifying the chemical effluents being detected. Detection and identification time should be minimal in order to prompt, if necessary, timely safety measures. Phase I: Investigate, identify, develop, and select the materials and software needed to produce a lightweight, hand-held chemical effluent detector. Hardware and software capable of using the information gathered by the detector should be evaluated for ruggedness, size, weight, and speed in identifying the effluent of interest.

Phase II: Develop and demonstrate a lightweight, hand-held prototype chemical effluent detector.

ARPA 93-096 TITLE: Optimization of Real-Time Communications for a Global Nuclear Proliferation Monitoring System

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop a low-cost, real-time communications system for global monitoring of nuclear proliferation.

DESCRIPTION: ARPA is interested in novel concepts for real-time communications systems to support global monitoring of nuclear proliferation. The communications concept must be optimized to support rapid, reliable data exchange at the lowest possible cost. Data will include parametric data, seismic wave-form data, nonseismic data (e.g., gamma ray spectra), data requests, system maintenance data, e-mail, etc. Locations to be interconnected include developed and underdeveloped countries, and remote sites with and without existing communications facilities. Data compression technology, shared networks, and space-based cellular communications are among potential areas to be investigated.

Phase I: Identify approaches and/or concepts, and design a plan for demonstrating the effectiveness of a communications system based on these approaches/concepts.

Phase II: Conduct an experimental program to test novel elements of the communications system, and demonstrate the feasibility of the system.

ARPA 93-097 TITLE: Assessment of Techniques for Nuclear Testing that Evade Detection, and Development of Monitoring Approaches to Counter Such Evasion Attempts

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop novel techniques that might be used by a nuclear proliferator to evade detection of nuclear weapons tests. Investigate monitoring methods that the United States might use to counter such evasion attempts.

DESCRIPTION: Identify novel methods that a potential nuclear proliferator might use to evade detection of nuclear weapons tests, e.g., conducting tests in the ocean or atmosphere. Conduct theoretical research to quantify the optical, acoustic and/or seismological signatures that would result from such evasion methods. Investigate methods that could be used by the U.S. or the global monitoring community to counter such evasion attempts.

Phase I: Describe the problem background and provide a conceptual, mathematical description of a novel method or methods that might be used to evade detection of a clandestine nuclear test. Design a plan for evaluating and/or conducting a scaled demonstration of the method(s).

Phase II: Based on the results of Phase I, conduct a full investigation of the evasion scenario(s), and develop methods that could be used by the U.S. or global monitoring community to counter such evasion attempts.

ARPA 93-098 TITLE: Laboratory and Theoretical Research to Predict the Effect of Decoupling on Various Comprehensive Test Ban Treaty Evasion Schemes

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Conduct scaled laboratory experiments and theoretical research to predict the seismological effects of schemes to evade the detection of nuclear tests under a comprehensive test ban treaty.

DESCRIPTION: ARPA and the Air Force are developing a plan for implementing a global network to monitor nuclear proliferation, as well as to verify compliance with a possible comprehensive test ban treaty. For maximum effectiveness, the network should be designed to insure detection of known evasion scenarios, such as cavity decoupling, or masking a small nuclear test with a large quarry blast. This project is to conduct theoretical research, supplemented by scaled laboratory experiments, to quantitatively assess the seismological effects of such evasion scenarios.

Phase I: Identify approaches to a combined theoretical/laboratory study of treaty evasion scenarios, and conduct preliminary calculations and laboratory tests to demonstrate the techniques that will be used in an expanded research program.

Phase II: Based on the Phase I results, conduct a program of research to quantify, under a range of geologic conditions and test yields, the seismological effects, at both short and long distances, of known evasion methods. Use the research findings to predict the character of seismic signals to be expected at various distances.

ARPA 93-099 TITLE: Photonic Radar Systems

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop new concepts and approaches in integrated radar system technology utilizing photonic elements to achieve significantly greater system performance.

DESCRIPTION: Photonic technologies have the potential to allow much greater radar system performance than can otherwise be achieved with conventional digital or analog signal processing. As a result, systems architectures which exploit advancements in photonic technology to achieve significant radar performance improvements are being sought. The fully integrated system must be capable of detecting very small radar cross-section targets, such as sea-skimming and cruise missiles; providing high-resolution range measurements; and reducing sensitivity to electronic countermeasures.

Phase I: Address concepts for and approaches to the development of photonic radar systems, identify the most suitable approach, and perform sufficient analysis and design to indicate a reasonable probability of success in Phase III for feasibility demonstration.

Phase II: Use the approach defined in Phase I to develop detailed system requirements, build and demonstrate selected critical system elements, and deliver a preliminary radar system technology demonstration design to the Government for evaluation.

Phase III: This phase is anticipated to transition the Phase II products to a specific application via design, resolution of unresolved production and manufacturing issues, and/or demonstration of a photonic radar system or subsystem.

ARPA 93-100 TITLE: Interference Rejection and Angle Estimation Techniques for Antenna Arrays with Uncertain Element Locations

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop effective techniques for beamforming in the presence of interfering signal sources and jammers with antennas whose element locations cannot be precisely controlled.

DESCRIPTION: Modern aircraft radar antennas can be deployed over extended portions of the aircraft surface. Beamforming with such antennas requires precise knowledge of the element locations. Such knowledge may be difficult or impossible to obtain by direct measurement due to flexing of the array. Techniques for adaptive cancellation of interfering signal sources are well-known, but can result in large errors in estimation of the angle of arrival of desired signals. In addition, computational requirements for adaptive processing can become very large if many degrees of freedom are required. This solicitation seeks to explore techniques for beamforming such an array. Algorithms need to be developed that can learn the time-varying locations of the antenna elements, possibly using information present in the clutter and jamming itself. Of particular interest are the quality and robustness of interference rejection, and the angle accuracy. Computational complexity is of concern, but is of secondary importance.

Phase I: A study containing a mathematical examination of alternative algorithms, and analyses resulting in the recommendation of preferred technique(s).

Phase II: A detailed simulation of the performance of the selected beamforming technique for an antenna configuration to be selected jointly by the contractor and ARPA.

ARPA 93-101 TITLE: Electrooptic Materials Development

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop an electrooptic material and associated manufacturing process that maximizes the electrooptic effect and minimizes the electroacoustic effect.

DESCRIPTION: One class of analog fiber-optic communications link utilizes the Mach-Zehnder device. This link consists of a laser light source that sends unmodulated light through a fiber to a Mach-Zehnder on a lithium niobate crystal. The Mach-Zehnder consists of a wave guide for the light on the surface of the crystal. The wave guide passes between two electrodes. A voltage applied to the electrodes will cause the light energy to be amplitude modulated and the modulated light is carried to a detector by another fiber. This link technology has applications in situations requiring a large bandwidth, and where the presence of conducting cables - e.g., coaxial cables - would otherwise cause other undesired effects. This link technology has application over a wide range of frequencies from a few MHz to more than 1,000 MHz. The technology takes advantage of the electrooptic effect in the lithium niobate material. An important problem that is prevalent at low frequencies - below about 200 MHz - is that lithium niobate also exhibits an electroacoustic effect. The application of a periodically varied voltage to the electrodes on the material will launch acoustic vibrations in the bulk of the material. These microscopic vibrations are sufficiently large enough that they alter the electrooptic properties in an undesirable manner. This can be shown by comparing the detailed bandpass characteristics between two links. In certain antenna applications the measurement of interest is called the cancellation ratio, which is the difference in the bandpass characteristics over a specified bandwidth. A desirable number is a ratio of 50 dB or more over bandwidths in excess of 100 kHz, for links operating at frequencies below about 200 MHz. The goal of this work is to identify a material having properties which minimize the electroacoustic effect and maximize the electrooptic effect. It is important that the new material also minimize the loss the light experiences while passing through the Mach-Zehnder pattern on the surface. It is also important that the voltage variation necessary to modulate the light from maximum intensity to extinction be on the order of about one volt.

Phase I: Perform a literature search on materials that have been tested in both electrooptic and electroacoustic applications to identify the most promising materials for testing.

Phase II: Develop techniques to embed light wave guides into the material surface and electrodes on the material's surface. Test the prototype devices for light loss, voltage required to modulate the light, and performance over temperature. Continue to fine tune the materials and techniques to develop a low-cost manufacturing approach.

ARPA 93-102 TITLE: Develop Ground Bounce Jammer Mitigation Techniques for Communication and Radar Systems Implementation

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop algorithms suitable for real-time implementation to suppress this type of interference.

DESCRIPTION: Communication and radar systems in aircraft are potentially vulnerable to jamming from another aircraft where the strategy is to bounce the jamming signal off the ground. The effect is to cause multipath jamming to come from a broad angular sector instead of a single direction, thereby complicating the usual nulling approaches with phased array antennas. However, the ground bounced multipath signal is a time delayed and doppler shifted replica of the transmitted jammer signal. Approaches to multipath interference in the past have employed either adaptive temporal processing or adaptive sub-band processing. The limitations of one or both of these mitigation techniques include: the fact that they require a large number of degrees-of-freedom to null the interference; their difficulty in dealing with the doppler shift of the ground bounce signal; and in the look-down radar case, a problem in dealing with radar ground clutter. Proposed techniques should specifically address these limitations and should not assume that a clean replica of the jamming signal is available by pointing a beam at the jammer.

Phase I: Perform a literature search on methods to model this phenomena and proposed solutions. Develop techniques which address the above issues and evaluate them. The Phase I deliverable would be a mathematical description of the proposed technique and the preliminary analytical or simulation results.

Phase II: Continue to fine tune promising techniques plus signal processor architectures to implement the recommended approaches. The Phase II deliverable would be an operation count and processor architecture.

ARPA 93-103 TITLE: Lattice Wing Technology for Maneuverable Towed Bodies

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop innovative lattice wing control surface concepts for controlling maneuverable towed bodies.

DESCRIPTION: Modern air vehicles may deploy towed bodies behind them in-flight to house off-platform devices. It is desirable to be able to maneuver these bodies off the longitudinal axis of the host platform. Lattice wing control surfaces appear to offer advantages over conventional wing or fin control surfaces in areas such as aerodynamic force generation, control power requirements, linearity, rigidity, and compact storage. This solicitation seeks to examine the characteristics of lattice control surfaces for this application. This includes cell spacing requirements, airfoil shaping effects, and aerodynamic stability. Of particular interest is the ability to generate large aerodynamic forces with small physical size.

Phase I: The Phase I product will be a study developing concepts for lattice wing control surfaces and describing their characteristics and capabilities.

Phase II: The Phase II product will be a prototype lattice wing controlled body suitable for demonstration either in a wind tunnel or as a full-scale towed model.

ARPA 93-104 TITLE: Photonic Hybrid Devices for Radar and Communications Systems

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop innovative photonic hybrid devices that maximize gain and dynamic range of radar and communication subsystems.

DESCRIPTION: Emerging optical and optoelectronic technologies have the potential to permit much greater radar and communication systems performance than can be performed by conventional digital and analog systems.

Increased system capabilities achieved by temporal, spatial, or wavelength multiplexing, coherent detection, optical routing and switching, etc., that result in significantly improved antenna gains, system/device noise figures, etc., are of interest in this solicitation. Proposed devices may be single elements that could be directly substituted in existing or advanced radar and communication systems, such as an optical mixer, or hybrid groups of optoelectronic elements that may replace complete functions, such as an optical corporate-feed subsystem. All proposed elements/modules must be compact, self-contained, and mechanically and thermally stable devices/subsystems that offer enormous advantages over conventional electronic systems.

Phase I: Design and develop optoelectronic concepts that can be physically scaled and implemented in advanced radar and communications subsystems.

Phase II: Demonstrate, test and deliver a practical application of a compact, survivable, and reliable optoelectronic device/subsystem that will significantly enhance radar/communications subsystem performance.

Phase III: These devices/subsystems could make a major contribution in inserting optoelectronics technology into advanced radars and communication systems. Strong possibilities exist that several ARPA/Service programs would consider using these devices/subsystems to support whatever optical signal conditioning or processing technology their particular program used.

ARPA 93-105 TITLE: Knowledge Query and Manipulation Language (KQML) Interfaces

CATEGORY: 6.3 Advanced Development

OBJECTIVE: Development and distribution of KQML interfaces, to be used in integrated manufacturing and planning domains.

DESCRIPTION: Research has developed and demonstrated the viability of a language that can be used to specify transport of complex information units among applications and information servers. The language serves as a layer or wrapper between transport protocols (such as e-mail or sockets) and declarative expressions of information units being transmitted for remote processing. The actual information units can be expressed in a variety of differing formats, such as: formal logic; statements as expressed in such high-level languages as PROLOG, LOOM, and CLASSIC; rules as employed in many expert systems; complex objects as handled in such languages as SMALLTALK, C++, and Ada; datastructures as used in record-based languages; or similar structures as stored in corresponding database systems. KQML names and transports, but does not attempt to understand, the meaning of these units. Since information units are likely to be context dependent, the KQML specifications include: (1) performatives, to drive inference and execution at the remote sites; (2) communications instructions, to define the conventions to be followed in transmitting a response; and (3) named ontologies, to provide for a match of the vocabulary that was used in expressing the information unit. A variety of Application Programming Interfaces (API) will be needed to enable application-oriented programs or expert systems to express their needs using the KQML conventions and to allow other applications or information servers to execute those requests. Some APIs must allow communication between systems using differing representation languages, via an intermediate interchange format. Some of these must satisfy needs as expressed in the F-22 IWSDB, PACT, and DRPI efforts.

Phase I: Deliver a documented, functional prototype of a server interface application. The documentation should specify which of the performatives listed in the KQML document have been implemented. Plans for long-term support and maintenance should be outlined.

Phase II: Complete a set of KQML compliant interfaces using performance information obtained by testing and analysis. The business case should indicate long-term viability.

ARPA 93-106 TITLE: Methods to Extract Annotations from Engineering Drawings and/or Maps

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Make legacy information now in engineering drawings accessible for maintenance and reuse.

DESCRIPTION: Engineering design information has been traditionally captured in engineering drawings. These drawings are usually large paper sheets, 24x36 inches or larger. These sheets contain both geometric data and text associated with portions of the geometry. To make such legacy information accessible for maintenance and use with newer CAD drawings and analysis tools, paper drawings must be converted to machine-readable representations. Most current research focuses on the geometry in existing paper drawings. An associated task is to extract nongeometric data on the drawings and associate it with the geometric data; examples of such data are: text, identifiers of components, industry standard symbols, measurements, tolerances, finishing instructions, connections, section references to other drawings, and title blocks. References on maps include depth, elevation contours, terrain descriptions, identifiers of natural and man-made features, man-made object descriptions, and other U.S. Coast and Geological Survey symbols. Text may be in printed, typed, lettered, hand-printed or written form. In addition, there is typically a specification block in one corner that includes spaces for approval signatures and corresponding dates. All this information should be extracted for labelling purposes. This research will provide methods to extract non-geometric data, create suitable files for further analysis, and support associating the entries with the geometric objects being represented digitally in those drawings. A convention should be established for illegible character sequences and unrecognized symbols. The goal is a complete, robust digital representation that captures all the syntax and semantics present in the original paper drawing. These digital representations should conform, as much as possible, to industry standards (such as those specified by IGES, PDES) for exchanging digital engineering data.

Phase I: Demonstrate base capabilities and create a plan for developing a product based on those capabilities.

Phase II: Develop and test modules in a realistic setting where both geometric and nongeometric data can be processed.

ARPA 93-107 TITLE: Methods, Support, and Languages to Control, Access, and Integrate Results of Simulation Programs from Remote Systems

CATEGORY: 6.1 Basic Research

OBJECTIVE: Bring the capabilities of modern simulation technologies into large and distributed, but at the same time maintainable and flexible, system architectures.

DESCRIPTION: Simulation is an important component of modern planning and decision-making processes. Today, most simulations are stand alone, that is, they are executed under direction of a user, who provides input information and inspects the results. Advanced simulation systems have been built that combine multiple simulations, allow activation through controlling programs, and distribute results for display at remote sites, in appropriate formats. Protocols are being developed to aid in the interpolation of simulations within certain domains. However, to improve the process of integrating simulations with each other and with other decision-aiding processes, new methods of system composition, support, and adaptation are needed. These new methods should: lead to reductions in cost and time for composition of systems involving simulations; increased flexibility and adaptability to changing needs, base capabilities, and system configurations; reduce the cost of system establishment and maintenance; and promote reuse of simulation components. Changes in needs may involve the precision, the time span, the due time, or the scope of a simulation. Changes in base capabilities can include improved access to data, increased computational power, as well as improvements in the models used in the simulations, perhaps adding parameters where no flexibility existed before. Systems configuration changes will include the number and accessibility of computational nodes, and perhaps connectivity to current measurements that allow improved simulation results. It is anticipated that languages and language-based tools will be needed to drive and support the creation and management of component-based simulations, so that changes, as listed above, can be rapidly and reliably expressed in high-level terms. Recompilation, rather than reprogramming, should be adequate to deal with most changes in the simulation environment, including replacement of simulator modules. The component simulations will execute in a widely distributed computing network environment and the natural parallelism of real-world events must be reflected in the language structure. It must be possible to express realistic constraints among the components, including real-time constraints, mismatch of real and simulation times, and failures of communication. The languages should be sufficiently formal to allow validation and verification of correct operation in real-time environments. They are likely to drive the evolving protocols used to control simulations, and affect their development; however, we expect that the actual simulations will continue to be developed in programming languages appropriate to their domain and heritage. Systems for composing simulations may require new programming environments. Proposals can be domain-specific, i.e., focus on a specific set of simulation applications and incorporate assumptions about the domain, or be more general. A more general approach is likely to require explicit declarations defining the domain, the system architecture, and the like. Domains can range from financial and budget planning, such as planning commonly done using spreadsheets, via simulations that evaluate the manufacturability, reliability, and even the marketability of products, to wide-ranging simulations that drive war-game exercises.

Phase I: Define the scope, the approach to method or language design and validation, a demonstration scenario, and the milestones of progress that can be applied to measure progress in this field. Planning of linkages to realistic experiments in Phases II or III of a possible award will be important.

Phase II: Due to the innovative nature of this topic we do not expect to award any Phase II contracts prior to the completion and evaluation of Phase I contracts.

ARPA 93-108 TITLE: Means to Facilitate Access to Public or Semi-Public Databases from Remote Systems

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Provide access to data and information compiled and maintained in public or semi-public databases, permitting its direct use by remote application systems.

DESCRIPTION: A large portion of the information relied on by planning, logistics, manufacturing, and other decision-makers derives from public and semi-public databases. We define semi-public as corporate or institutional databases that contain information that is available for use by select customers. Such databases include electronic reference libraries; airline, airfreight, rail, trucking and shipping schedules; weather, road and traffic information and predictions; supply, location, and other resource data; and rules and laws governing processing and shipping. Unfortunately, most of this information is either inaccessible or only accessible in formats that cannot readily be incorporated into automatic data-processing. This lack of database information leads to requirements for manual transcription and, in practice, to inefficient use of available facilities and resources. It is hoped that access to such information will become more conveniently accessible via the communication networks now being established. Data requests and responses should satisfy extant and emerging standards as far as practicable. Access to descriptive meta-data must be available as well, so receivers do not need to program extensive knowledge about the content, formats, scope, and significance of information. Arrangements must be made to inform users of changes in the meta-data, to enable rapid and economical maintenance of using programs. Consideration should be given to means of recording and monitoring accesses, with an eye to possible billing or other means of service reimbursement. Proposals should not only be technically correct, but should show that there is potential for a viable and long-lived business.

Phase I: Provide a coherent plan, including financial viability, of providing access to one or more valuable databases, and establish credible linkages with the owners of such data.

Phase II: Initiate an actual service to one or more such databases in its time frame, provide means for measuring its utilization, and quantify the costs and benefits of the service.

ARPA 93-109 TITLE: Advanced Multimedia Imaging Helmets

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop advanced multimedia imaging helmets for ship and ship systems design, construction, operation, and maintenance tasks.

DESCRIPTION: There is a need to develop advanced multimedia imaging helmets to provide a rich and robust interface between mobile operators and distributed, intelligent, highly automated computer-based systems. Concepts for one or more variants of a family of such helmets are required. As an example, the range of possible applications for ship and ship systems "operation-related" tasks includes, but is not limited to, development of helmets for mobile shipboard operators (command, fire control, damage control, machinery control, etc.) who must sense, process and display data locally while maintaining connectivity with other remote stations and operators and their distributed sensing, processing and display functionality. As a part of this effort, innovative concepts are sought for sensing, fusing and displaying multispectral imaging data with computer generated 3D CAD, text, and auditory representations in a helmet-based system, while at the same time permitting the operator normal visual and auditory sensing.

Phase I: Provide a conceptual design for one or more variants of a family of advanced imaging helmets. Demonstrate the extendibility of proposed concepts to related applications and provide a performance, cost and development risk trade-off analysis with appropriate metrics.

Phase II: Design and demonstrate a full-scale prototype of one or more variants of the proposed family of imaging helmets. Conduct performance and cost sensitivity analysis to demonstrate concept viability.

ARPA 93-110 TITLE: Intelligent Robotic Cranes and Fixtures for Manufacturing of Ship and Ship Systems

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop and demonstrate an intelligent and advanced, adaptable robotic cranes and test, fabrication, and assembly fixtures for manufacturing of ships and ship systems.

DESCRIPTION: There is a need to develop concepts for advanced, adaptable robotic cranes and test, fabrication, and assembly fixtures to support the automation of component manufacturing and construction-related processes for ships and ship systems.

Phase I: Provide a conceptual design for an intelligent, adaptable robotic crane or fixture and demonstrate the feasibility and potential of the proposed concept. Quantify performance characteristics and establish the expected constraints and limitations of the proposed concept through a combination of simulations, analysis, computations, and physical experiments. Provide performance, cost and development risk trade-off analysis of selected design alternatives with appropriate metrics.

Phase II: Design and demonstrate a full-scale simulation and a subscale implementation of the proposed robotic crane or fixture. Conduct performance and cost sensitivity analysis to demonstrate the viability of the proposed design.

ARPA 93-111 TITLE: Advanced Marine Internal Combustion Engines

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop, for military application, advanced internal combustion engines with high power-to-weight ratios and low emissions and specific fuel consumption.

DESCRIPTION: Present marine engines fall into four major categories: high speed, medium speed, and low speed diesels, and open brayton cycle gas turbines. There is a need to develop and demonstrate advanced engine concepts, such as advanced diesel or closed brayton cycle engines, with power densities of less than two lbs/HP, that have favorable specific fuel consumption and emissions over a wide range of speeds and mission scenarios.

Phase I: Provide a conceptual design for an advanced internal combustion engine. Demonstrate the viability of the concept through a combination of simulations, computations, analysis, and subscale demonstrations. Provide a performance, cost and development risk trade-off analysis with appropriate metrics.

Phase II: Design and demonstrate the viability of the design through a combination of subscale and high-risk component demos, simulations, and analysis. Conduct performance and cost-sensitivity analysis of the proposed design.

ARPA 93-112 TITLE: Intelligent Planning and Control Systems for Rapid Response to and Mitigation of Maritime Oil Spills

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop concepts for oil spill response, including containment, mitigation, remediation, cleanup, disposal, monitoring and control using advanced air and surface deployed robotic marine vehicles. Incorporate advanced technologies from industry and ARPA.

DESCRIPTION: There is a need to develop concepts for the planning, deployment and control of advanced, intelligent systems for the rapid response to and mitigation of maritime oil spills. System concepts consisting of both air and surface deployed assets and incorporating technologies such as advanced robotic vehicles, artificial intelligence, advanced sensors, advanced materials, etc., are required to insure rapid and efficient planning and response to oil spill situations involving a wide range of both environmental and casualty-dependant constraints. Proposals should focus on high-payoff specific technology elements, as well as the performance and cost of overall system concepts.

Phase I: Provide a conceptual design for a planning, deployment and control system for the containment, mitigation, remediation, cleanup, disposal, and post-spill monitoring of maritime oil spills. Demonstrate concept feasibility through a combination of simulation and analysis. A trade-off analysis with appropriate metrics is required.

Phase II: Design and develop a full-scale simulation prototype for the integrated system and appropriate subscale software and hardware prototypes of selected high-payoff and innovative technologies and components. Conduct performance and cost-sensitivity analysis to demonstrate the viability of the concept design.

ARPA 93-113   TITLE: Advanced Embedded Sensors and Intelligent Control Systems for Internal Combustion Engine Performance Monitoring and Control

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop advanced embedded sensor and intelligent control systems for the performance monitoring and control of internal combustion engines.

DESCRIPTION: There is a need to develop advanced embedded sensor and control system technologies to sense, fuse and process the diverse parameters associated with the performance monitoring and control of current and advanced internal combustion engines. Innovative intelligent sensor and sensor-processing technologies, ranging from microdynamic to fiber-optical, as well as other specialized discrete and array technologies are required. Artificial intelligence based software components to fuse, assess, reason, plan, and otherwise control the performance and emission-related parameters of such engines are required.

Phase I: Design and demonstrate a full-scale prototype of the proposed design. Conduct performance and cost-sensitivity analysis to demonstrate the viability of the concept.

Phase II: Provide a conceptual design for selected engine sensor(s) and/or for an intelligent performance monitoring and control system. Demonstrate the viability of the proposed concept through a combination of computations, simulations, analysis and subscale demonstrations. Provide a performance, cost and development risk trade-off analysis with appropriate metrics.

ARPA 93-114TITLE: Dolphin/Bat Signal Processor and Classifier

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop a sonic receiver, signal conditioner, signal-processing algorithm, and a neural-net realization of either the dolphin or bat sonar signal-processing system.

DESCRIPTION: Both the bat and the dolphin use high-frequency sonar to locate prey. Although these systems are radically different, both require the reception and processing of short-duration signals. The goal of this program is to develop a supervised neural network and signal processor that can be adapted to mimic either the dolphin or bat sonar. The project will also require development of a receiver, signal conditioner, and processing algorithms for either the dolphin or bat sonar. Emphasis should be placed on both the echo location capabilities of the sonar and the classification capabilities. If the neural-net technology is capable of satisfying both systems, then the work should incorporate a flexible architecture such that both can be treated in a sequential manner. The results of this effort will be used to study the echoes produced by both real animals and artificial means.

Phase I: Develop signal-processing schemes that are based on current research efforts at universities and naval laboratories for both the dolphin and bat sonar. Upon selection of either the bat or dolphin sonar, a receiver, signal conditioner, processing algorithm, and neural system will be designed and its applicability to the other animal assessed. The output from Phase I will include the candidate system design, a comparison of the bat and dolphin processing systems, and the specifications for procurement of prototype components.

Phase II: Procurement, assembly and laboratory testing of the neural-net processing. The laboratory testing should concentrate on the training of the net on artificial signals. After successfully completing the laboratory testing phase, the device should be field tested with both artificial and real signals. It is expected that during this phase the contractor will participate in the conduct of experiments using this device. The final report should discuss the applicability of this device to the dolphin/bat sonar not studied and make relevant recommendations regarding future applications.

ARPA 93-115 TITLE: Dolphin Sonar Transducer and Array

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop and build a transducer and focusing array that duplicates that of the dolphin.

DESCRIPTION: The dolphin has a unique sonar capability by which it produces high-frequency clicks. The Dolphin's forward-looking sonar beam is most likely produced with its larynx, then conditioned in the nasal passage wave guide and focused by the melon. The dolphin is able to vary both the frequency content and the repetition rate of the clicks. The goal of this project is to model the dolphin sonar and to design, construct, and build a transducer capable of mimicking the dolphin's behavior and ultimately to use this device to simulate the dolphin's ability to recognize objects.

Phase I: Phase I will consist of the modeling of the sonar and the performance of both laboratory and analytical studies to demonstrate the adequacy of the model. A prototype transducer and focusing array will be designed.

Phase II: The transducer/array will be fabricated, built and laboratory tested. Finally, the device will, in conjunction with designated Naval Laboratory personnel, be field tested and compared with the actual signals emitted by a dolphin and will be used in conjunction with recognition studies.

ARPA 93-116 TITLE: Sensors and Technologies for Fiber-Optic Sensing Systems

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop sensors and sensor technologies to be applied to fiber-optic sensing systems which will involve large numbers of miniature sensors on fiber-optic cables. The principle military application is underwater sensing.

DESCRIPTION: Arrays of underwater sensors are useful to the Navy. Rapid deployment of the sensors from an unmanned undersea vehicle or an airplane requires that the sensors and their cables be small, light, and easily unwound from a reel. For the cable to be small, it must use fiber-optic telemetry with the large number of sensors multiplexed on a small number of fibers. The sensors must be small enough not to interfere with the deployment mechanism. This project will develop the multiplexed sensors.

Phase I: Complete a preliminary design for the sensors and their multiplexing. Analyze critical issues of the design and demonstrate experimentally as necessary. Show that the sensors and cable will be small and lightweight when combined. Show how the sensors can be transitioned to production and how effective the sensors will be for military applications.

Phase II: Build and demonstrate arrays of multiplexed sensors. Show the performance that can be expected under a range of conditions. Develop an estimated cost of the sensors in production quantities. Develop a plan for transition of the sensors to production for civilian and/or military applications. If production will be for civilian applications, show how the same technology can be used to support military applications.

ARPA 93-117 TITLE: High-Density and Safe Storage for Unmanned Undersea Vehicles and Electric Land Vehicles

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop high-density and safe hydrogen storage systems to be used on unmanned undersea vehicles or other submersibles, or on electric land vehicles. Refueling should be accomplished either by refilling a tank with fluid or by replacement of a canister.

DESCRIPTION: Unmanned undersea vehicles, other submersibles, and electric vehicles can be powered efficiently and quietly by Proton Exchange Membrane (PEM) fuel cells, which require hydrogen as a fuel. For use of PEM fuel cells to be successful, refueling must be rapid and safe and large amounts of hydrogen must be stored on-board. On submersibles or electric vehicles, the PEM system will be advantageous only if the energy density of the system exceeds that of secondary batteries. In the case of submersibles, the specific goal is to reach and, preferably, to substantially exceed the energy density of liquid hydrogen. Both electric vehicles and submersibles can be refueled by refilling a tank with fluid (liquid or gas). Such systems could support rapid refueling, however steps must be taken to assure that the fuel is safe to handle. Alternatively, in the case of submersibles the hull may be opened in order to allow refueling by insertion of a canister containing the fuel or containing a chemical from which hydrogen can be generated.

Phase I: Complete a preliminary design of the hydrogen storage system and, as necessary, demonstrate critical issues experimentally. Show how the hydrogen storage system can be transitioned to production and how effective the hydrogen storage system will be for military applications.

Phase II: Build and demonstrate the hydrogen storage system. Develop an estimate of the cost of the storage system for submersibles and electric land vehicles. Develop plans to transition the system to production for civilian and/or military applications. If production will be for civilian applications, show how the same technology can be used to support military applications.

ARPA 93-118 TITLE: Compact and Efficient Reformer to Supply Hydrogen for Proton Exchange Membrane (PEM) Fuel Cell Stacks

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop a compact and efficient reformer to supply hydrogen for PEM fuel cell stacks. The reformer should be suitable for use in transportable equipment or vehicles.

DESCRIPTION: PEM fuel cells can convert hydrogen efficiently and cleanly into electricity. Hydrogen can be supplied by reforming hydrocarbon fuels such as methanol. A compact, efficient, reformer is required for transportable equipment and vehicles. The reformer must be able to follow the load, operate with minimal environmental impact, and generate a hydrogen stream compatible with PEM fuel cells. In particular, carbon monoxide levels must be low.

Phase I: Complete a preliminary design of the reformer and demonstrate critical issues experimentally as necessary. Show how the reformer can be transitioned to production. Also, show how effective the reformer will be for military use in transportable equipment or vehicles.

Phase II: Build and demonstrate the reformer. Show compatibility with a PEM fuel cell stack. Develop a cost estimate for the reformer produced in production quantities. Develop plans to transition the reformer to production. If production will be for civilian applications, show how the same technology can be used to support transportable equipment or vehicles for the military.

ARPA 93-119 TITLE: Components for Low-Cost, High-Performance and Robust Proton Exchange Membrane (PEM) Fuel Cells

CATEGORY: 6.2 Exploratory Development

OBJECTIVE: Develop new components required for low-cost, high-performance and robust PEM fuel cell stacks for undersea vehicles and electric land vehicles.

DESCRIPTION: PEM fuel cell stacks offer advantages for a number of applications. In order to realize these benefits it is necessary to improve on available stack technology. The goal of this project is to make and implement the required improvements. The list of desired improvements/characteristics includes: long life, low leakage, easy manufacture and assembly, low cost, ability to handle impure reactants, simplification of support hardware requirements, higher efficiency and power density, and reduced susceptibility to membrane dry-out. Areas/issues possibly relevant to achieving the project goal include electrolyte membranes, catalysts, fabrication methods, seals, reactant gas conditioning, low-cost subassemblies, and simplified stack construction.

Phase I: Complete a preliminary design of the new components and demonstrate, as necessary, critical issues involving their performance or manufacture. Show how the components can be transitioned to production. Show how effective the components will be for improving the cost, performance, or robustness of PEM fuel cell stacks for undersea vehicles or electric land vehicles.

Phase II: Build and demonstrate the new components for PEM fuel cell stacks. Develop a cost estimate for production quantities of the components. Develop a plan to transition the components to production. If production will be for civilian applications, show how the same components or technology can be used to support military applications.