U.S. Army 94.2
Submission of Proposals

Topics

The Army has identified 100 new topics for this solicitation, which address Critical Technologies especially relevant to be Army, the Army Science and Technology Master Plan, and the STAR 21 Strategic Technologies for the Army of the twenty-first century. An attempt has also been made to identify the commercial potential of these initiatives.

Dollar Caps

The maximum dollar amount from the SBIR budget for Army Phase I awards is $70,000. Additional program dollars may be added by the program activity. To reduce the funding gap between Phase I and Phase II, firms may submit an option task not to exceed $30,000 with the Phase I proposal. Exercise of such an option would be intended to allow Phase II preparatory work to be initiated; however, the option does not obligate the Army to make a Phase II award. Firms who are awarded the option should reflect the funds as a deduction on the total cost of their Phase II proposal. Future Army Phase IIs will average about $600,000. Those companies who have been invited to submit a Phase II proposal and have almost finished their Phase I work must submit a plan on how they will commercialize the technology with the government or with the private sector. This commercialization plan is required in addition to the descriptive technical portion of the proposal if they desire to compete for a Phase II. Cost sharing options in Phase II are encouraged and will be used as an evaluation factor for proposed Phase IIs over $600,000.

Army Science and Technology Areas

The Army topics have been grouped into the ten Army Technology Areas listed below. Descriptions of these areas are provided on the following pages.

A-1Advanced Materials and Manufacturing (Structural & Energetic Materials)
A-2Microelectronics and Photonics
A-3Sensors and Information Processing (Communications)
A-4High Performance Computing, Communications, Networking, and Simulation (Modeling Displays, AI, Virtual Reality)
A-5Advanced Propulsion Technologies (Mobility and Lethality)
A-6Power and Directed Energy
A-7Biotechnology
A-8Life, Medical and Behavioral Sciences
A-9Environmental and Geosciences
A-10Engineering Sciences (Robotics, Dynamics, Structures, Mechanics, and Construction)

Industry-Generated Future Topics

To enhance industry involvement in the Army SBIR process, I welcome suggestions from small firms for future Army topics. Kindly forward your topics to Mr. Joe Forry **after** this solicitation. Unsolicited proposals will not be accepted.

LTC John Peeler
Army SBIR Program Manager

Inquiries only (do not send proposals to the address below)

HQDA

OASA (RDA)
Pentagon, Room 3D318

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DESCRIPTIONS OF THE TEN TECHNOLOGY AREAS

AREA 1: Advanced Materials and Manufacturing

Advanced material technologies will significantly improve Army capabilities by providing lighter weight, stronger, and more durable materials that will improve the performance and efficiency of soldiers and their battlefield systems. Advanced materials and manufacturing incorporates the synthesis, processing, characterization, and predictive modeling of materials, as well as manufacturing technologies to reduce the time, risk, and cost of acquiring materials. Increasing demands on future battlefield systems will require tailor-made materials and structures with major performance improvements. In addition, requirements for cost reduction and reliability enhancement will continue to push the limits of manufacturing science and technology.

AREA 2: Microelectronics and Photonics

Microelectronics and photonics technologies underpin all Army systems for signal acquisition, communication, computation, and processing. As the heart of Army systems, these technologies establish how well battlefield devices (such as smart weapons, fire control systems, warning receivers, electronic warfare gear, and intelligence collection devices) will perform. Microelectronics includes such technologies as smart high-resolution displays and hybridized integrated circuits. Photonics uses light to represent, manipulate, and transmit information which includes such technologies as integrated optics and fiber optic technology.

AREA 3: Sensors and Information Processing

Sensors and information processing technologies have become the brains of modern weapon systems by providing quick and accurate information about troop positions, target locations, and battlefield conditions. Sensors and information processing include the application of sensors and signal processing for acquiring, developing, fusing, and disseminating information on target identification and location. Sensors should operate throughout the electromagnetic and acoustic spectrums. Sensor technology includes active, passive, imaging, non-imaging, line-of-sight (LOS) and non-line-of-sight. Information processing includes preparing and analyzing detector fronted signals, developing information and fusing information from multiband sensor networks, and forming communication links and communication networks where information is integrated and displayed.

AREA 4:High Performance Computing, Communications, Networking and Simulation

High performance computing, communication, networking and simulation are necessary to achieve an electronic battlefield where material and doctrine development, training, and research can be accomplished synergistically. It focuses on technology development to assure Army specific requirements are inserted into the Battlefield Distributed Simulation-Developmental (BDS-D) process and other simulation applications. This technology encompasses computing and communication, system representation and integration, physical environment representation, interface factors, and human characteristics and representation.

AREA 5: Advanced Propulsion Technologies

Advanced propulsion technology provides the muscle for Army land combat systems: aircraft, vehicles, guns,

missiles, and soldiers. These systems coupled to modern doctrine, tactics, and training provide our soldiers the capabilities needed to dominate maneuver battles. Increased (propulsion system) power-to-weight and reduced fuel consumption lead to more compact, better performing, less vulnerable platforms. Improvements in range and lethality of guns and missiles depend on the availability of propulsion systems and survivable, energetic materials with very high rates of energy output. Advanced propulsion technologies include such technologies as ground vehicle transmissions/engines and ballistic propulsion.

AREA 6: Power and Directed Energy

Advanced technology development in power and directed energy will give the Army a distinct offensive and defensive advantage over adversaries. Critical areas for Army energetic power sources include a need for reduced cost, very high-energy density stealthy power sources for C3I missions, laser countermeasures devices, night vision devices, laser designator, smart munitions, tank silent watch, and future soldier systems. Man-portable systems requirements desiring very high-power and energy densities, including reductions in weight and volume, must be met with safe and low-cost power sources. The three principal divisions of requirements for Army technology in directed energy include lasers, High-Power Radio Frequency (HPRF), and particle beams.

AREA 7: Biotechnology

Biotechnology contributes to Army functions in many important ways from environmental remediation to improved soldier endurance and recovery. The Army uses biotechnology for medical and non-medical products and processes. The medical applications include disease prevention, defense against biological and chemical weapons, therapeutic interventions, diagnostics of infectious diseases, and sustainment of performance. The non-medical applications include chemical and biological (CB) defense, bioremediation, demilitarization, food technology, and materials design and manufacture.

AREA 8: Life, Medical, and Behavioral Sciences

Potential threats to soldier health and welfare have increased in deployments to a variety of worldwide geographical and climatic conditions. Army research needed in life, medical, and behavioral sciences address the development of technologies to protect, sustain, and restore the health of soldiers and units. Research requirements include food and nutrition technologies as well as medical technologies for improved vaccines, drugs, therapies, diagnostics for infectious diseases, chemical and biological defense, traumatic battle injuries and casualty care, combat dentistry, and treatment of soldier stress. Research in behavioral science and technology enhances soldier-system performance.

AREA 9: Environmental and Geosciences

Environmental and geosciences research encompasses the physical environment where the Army lives, trains, tests, and fights. Research also considers the effects of the environment on material, personnel, and tactics. Environment and geosciences technology includes environmental clean-up; identification of nuclear, biological, and chemical (NBC) hazard zones; and maintaining training and testing lands for continued safe use.

AREA 10: Engineering Sciences

Army disciplines for engineering sciences are principally focused in structural mechanics, fluid dynamics, control theory and control systems, and systems engineering and integration. Engineering sciences offer significant improvements in system efficiency, durability, performance enhancements, and cost savings throughout the Army's infrastructure. Research in engineering sciences includes design, modeling, and fatigue and failure analyses in structural mechanics; fluid dynamics methodologies; control theory and integration; experimental simulation; and systems engineering.

ARMY SMALL BUSINESS INNOVATION RESEARCH

Submitting Proposals on Army Topics

Phase I proposal (5 copies including 1 red-printed form) should be addressed to:

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DEPARTMENT OF THE ARMY
FY1994 TOPIC DESCRIPTIONS

A-1ADVANCED MATERIALS AND MANUFACTURING
(I.E. STRUCTURAL & ENERGETIC MATERIALS)

TOPIC: A94-001TITLE:Advanced Tungsten Alloys
Point of Contact: ARDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop tungsten-based materials which display sufficiently enhanced terminal ballistic performance so as to replace depleted uranium alloys as material of choice for DOD munition applications.

DESCRIPTION: A new generation of tungsten-based material is needed to exhibit terminal ballistic performances equivalent to depleted uranium alloys. These new tungsten-based alloys will be designed to display an early onset of dynamic plastic instability and flow localization. This may be accomplished by configuring new matrix material and modified and enhanced tungsten particles into particulate composites having appropriate characteristic microstructures and thermomechanical properties that induce the desired flow localization in the material. An alternate concept to promote enhanced ballistic performance in tungsten alloys relies on the orientation aspects and the anisotropic flow behavior of tungsten. Based on the very superior ballistic performance of <100> oriented tungsten single crystals, various approaches may be explored to impart similarly favorable orientation in polycrystalline tungsten and tungsten composites.

Phase I: Demonstrate concepts for advanced tungsten alloys to display dynamic plastic instability and flow localization. Deliver material for evaluation.

Phase II: Scale-up processing, as necessary. Prepare material for high strain rate screening and sub-scale ballistic testing.

Potential Commercial Market: The technology developed under this program will allow advancement in both military and commercial fields. Alternate material will replace the environmentally sensitive depleted uranium in all of the DOD munition application. Particularly, for the Army, this technology can be used in programs such as SADARM, replacement for 829A1 KE round, hypervelocity projectiles and x-rod program. Commercial benefits include the use for gyroscopes, counter balances, semiconductor substrates, radiation shields, machine tools and medical equipment. Operations and Support Cost Reduction: New generation of tungsten alloys developed under this program will markedly reduce the environmental, logistical and life cycle cost burden associated with the present use of radioactive depleted uranium material i n all of the DOD armament components.

TOPIC: A94-002TITLE:Modular Omnibus Program With Internal Checking
Point of Contact: ARDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop an modular omnibus program with internal testing (MOPIT) which has the capabilities for designing molecules, modeling various fundamental and applied physico-chemical phenomena associated with propulsion systems and with energetic and non-energetic materials.

DESCRIPTION: Individual Computer codes to model specific propellant systems and solid and fluid propulsion

phenomena and associated data bases have been developed at ARDEC. These include software to model equilibrium chemistry (MCVECE), reaction kinetics (PANDORA), reactive chemistry/hydrodynamics (VULCAN), droplet formation and size distribution, and molecular dynamics. Along with these modeling codes, dynamic color graphics have also been developed which give real time visual simulation of the modeling output. In addition, other codes developed elsewhere are also available that predict molecular structure, thermodynamic parameters, and model explosive processes. These codes are used individually at ARDEC to design and characterize energy parameters of new molecules; screen molecules as potential candidate propellant or explosive ingredients and their potential formulations; model propellant combustion and interior ballistic cycles; predict potential propellant and explosive performance; and, model environmental impact. Other military application of these codes include modeling processes involving munitions production, munitions demilling, and their environmental impact. An even greater number of applications are possible in the commercial sector.

Although these computer codes are available, utilizing them in an efficient integrated interactive way is currently not possible without specific detailed knowledge of the individual codes. That is to say that data, parameter and variable compatibility between programs and simulation tasks must be established and maintained. Specifically, what is needed is a program which: 1) automatically examines simulation task requirements against the available modules and their respective functions and input requirements; and, 2) after this examination interrogates the user to supply input that may be lacking or needs modification.

To develop a new propellant, it would be possible to design a candidate propellant oxidizer, predict its thermodynamic parameters, optimize a propellant formulation with a given fuel, simulate its interior ballistic cycle and predict its performance automatically by imputing an educated guess of its molecular structure into a properly structured MOPIT. In a similar fashion, a newly proposed propulsion concept could be modeled so that a rapid economic evaluation of its merit could be made.

Phase I: Develop an initial MOPIT infrastructure. Demonstrate the feasibility of the MOPIT concept utilizing only a few selected programs as a preliminary program library. Perform preliminary MOPIT modeling and simulation investigation of two tasks. Model same tasks with individual unlinked programs and provide analysis which compares the MOPIT results with the results from the individual unlinked programs.

Phase II: Expand the initial MOPIT developed in Phase I by accumulating and evaluating an extensive library of programs to be used in MOPIT. Standardize name convention and units for all variables and constants in the candidate modular programs. Structure MOPIT to be language independent so that it can accept and interact with new programs written in different languages and automatically perform desired modeling. Provide MOPIT software capable of modeling a broad spectrum of tasks which address propulsion related phenomena complete with source code and documentation.

Potential Commercial Market: The software developed under this program can be utilized for any physico-chemical process and therefore has many military, commercial and academic applications. For example the designing and manufacture of exotic materials such as semiconductors and pharmaceuticals could be modeled with this MOPIT. For environmental impact studies the chemistry and physics of processes can be modeled and the evolution and spatial/time path of pollutants c an be tracked.

OSCR: Use of this MOPIT software will provide a means of rapidly evaluating proposed energetic materials and propulsion systems based upon fundamental parameters rather than on lengthily empirical data. This reduces the labor requirements and costs markedly throughout the research and development cycle.

TOPIC: A94-003TITLE:Powder Injection Molding
Point of Contact: MD

CATEGORY: Exploratory Development

OBJECTIVE: Develop advanced techniques, materials and/or equipment necessary to produce high quality powder

injection molded components

DESCRIPTION: Powder injection molding offers the opportunity to form components to net-shape through the use of particulate materials. Usually, a feedstock of metal or ceramic powders blended with molten polymer binders is injected into dies in a manner identical to polymer injection molding. The formed parts in the as-injected molded condition are called "green". After molding, the polymer binder is no longer needed and is usually removed from the formed part by a combination of solvent and thermal debinding; the remaining metal or ceramic powder, brown part, retains the formed shape. These debound parts are then centered in the usual way. Powder injection molding is a process that is capable of producing complex metal and ceramic components at a great cost savings. If the process is to become fully successful then the parts produced must be made with a reasonable degree of confidence in the finished part. That is with a low rate of internal defects and a high level of quality. It must also be produced in a manner that is benign with respect to the environment. Proposals are sought that address the technical problems of powder injection from any of a number of possible avenues. In no particular order, these may include, but are not limited to: (a) NDT of green (as-molded) components, (b) environmentally compatible binders and debinding agents, (c) injection molding od difficult to machine materials, (d) Modeling of the molding process particularly as it relates to final part quality, or (e) any aspect of the process seen as needing investigation.

Phase I: Identify and develop advanced methods for the production of high quality powder injection molded components. Demonstrate the appropriateness of the methods for the applications. Deliver demonstration components produced with the techniques, methods or procedures developed. All Phase I work should concentrate on one or two types of material, e.g., stainless steel, tungsten alloy, intermetallic, composite, ceramic, etc. so as to concentrate on developing the innovation.

Phase II: Work in Phase II should exploit the Phase I success, expand the range of materials and begin to apply the methods developed to production-like situations. This work should highlight the generic nature of the developed material, process or method and deliver prototype or demonstration components. The work in powder injection is inherently dual-use and demonstration components should reveal this aspect of the process.

Potential Commercial Market: The potential market for powder injection molding has been identified to be well over $100 million. Successful expansion of this market will necessitate the production of consistent high quality parts and component s. Development of NDE methods, environmentally compatible materials and processes, and techniques to produce complex or difficult to machine components will facilitate this market expansion.

TOPIC: A94-004TITLE: Low Cost Processing of Whisker and Particulate Reinforced, Aluminum, Metal Matrix Composite, Thick Sections

Point of Contact: MD

CATEGORY: Exploratory Development

OBJECTIVE: Develop a low cost processing method by which thick-section (>2 inches), near-net shape, discontinuous, ceramic-reinforced, aluminum, metal matrix composites can be produced.

DESCRIPTION: Recent research on the ballistic behavior of discontinuous aluminum metal matrix composites (Al MMCs) demonstrated promising behavior. Results suggest enhanced penetration resistance with a fine grain Al MMC produced by thermomechanical processing over monolithically produced counterparts. Agglomeration of reinforcement along flow lines from deformation processing can be detrimental to spallation. A combination of whisker and particulate reinforcement i n forming a hybrid MMC may alleviate this predicament. Processing such Al MMCs via current powder metallurgy or rapid solidification techniques is relatively expensive, and heat extraction may be an obstacle when using these methods to produce thick sections (> 2 inches). Though low cost wrought and cast Al MMCs are available; their strength, ductility, and toughness are either lower or only comparable to their respective monolithic counterparts. The focus of this topic is to exploit innovative low cost thick section processing capabilities

for the fabrication of Al MMCs with the proper microstructure for structural armor applications. The ability to tailor the composite for reinforcement loading and control of the matrix grain size is crucial. Furthermore, the process is required to maintain homogeneous and uniform reinforcement distribution and a fine grain matrix microstructure throughout the thickness up to, but not limited to, 2 inches. The processing system must be flexible to handle all conventional aluminum alloy chemistry, including lithium additions, and should have potential as a continuous process.

Phase I: Demonstrate the feasibility and capability of a low cost processing method with extensive flexibility in process control for tailoring reinforcement loading and matrix grain size while producing thick sections of discontinuous whisker and particulate reinforced AL MMCs. Deliver six 12x12 by at least one inch thick AL MMC plates for ballistic screening tests.

Phase II: Develop optimized processing parameters for whisker and particulate reinforced Al MMC plates (at least 2 inches thick) and thick tubes. Produce and deliver thick section prototypes of armor plates and tubular components for property, microstructural and ballistic evaluations.

Potential Commercial Market: A low cost processing method for producing near net shape, high performance, AL MMC components would attract applications in the automotive, construction and agricultural industries.

TOPIC: A94-005TITLE:Development of Electron-Beam Curable Resins for Primary Composite Structural Applications

Point of Contact: VSD

CATEGORY: Exploratory Development

OBJECTIVE: Develop electron-beam curable resins for primary composite structural applications.

DESCRIPTION: Fabrication cost is the primary hinderance for the broad use of composite materials to primary structural applications. Structural resins that are both heat and electron-beam curable offer a significant potential for reducing the fabrication cost of primary composite structures. These resin systems should be compatible with yarn powder coating technology and particle toughening technology (i.e., rubber or thermoplastic) to improve damage tolerance. The mechanical properties, both at room temperature and hot-wet conditions, of the cured net resin should be consistent with properties from state of the art structural resin systems used in composite materials.

Phase I: Identify available structural resin systems (applicable to aviation and ground vehicles requirements) that are currently heat and electron-beam curable or can be modified to be heat and electron-beam curable. Conduct mechanical property tests on those resins systems using heat curing, electron-beam curing and a combination of heat and electron beam curing. Identify the most promising resin systems and prepare a detail approach as to how these resin systems can be modified to achieve the desired curing characteristics and mechanical properties.

Phase II: Modify the selected resins and conduct mechanical property tests of the cured neat resin materials. Several modification and test cycles may be necessary. Select one or two resins for evaluation as composite material. Conduct mechanical property tests of the composite materials.

Potential Commercial Market: Structural resins that are both heat and electron beam curable offer a significant potential for reducing the fabrication cost of primary composite structures and would be utilized in all composite manufacturing, both with military and commercial use.

TOPIC: A94-006TITLE:Functionally Gradient Ceramic-Titanium Metal Materials

Point of Contact: WTD

CATEGORY: Exploratory Development

OBJECTIVE: 1. Expand the existing commercial technical capabilities in functionally gradient materials (FGM) to specific armor-related materials and technology under 6.2 development in WTD. 2. Demonstrate the technical feasibility of ceramic-faced, titanium appliques for use in near-term light and medium vehicle applications where vehicle integration factors are paramount. 3. Emphasize existing FGM technology that has a commercial basis on which to solidify a strong dual-use capability.

DESCRIPTION: STATEMENT OF PROBLEM - The Armor Mechanics Branch has a number of separate 6.2 research programs funded under the ARL's AH80 Armor Technology Techbase program as well as under TACOM's DC05 Passive Armor Technology Program. Two programs of interest have been the development of low-cost titanium alloys for ballistic application and the evaluation of high performance ballistic ceramics. These programs have also been supplemented through various unfunded study agreements with Industry that provide the material support and development. Recently, the amalgamation of these two technologies into functionally gradient materials has been noted by at least two commercial firms that have strong armor materials background. Functionally gradient materials are in homogeneous composites which transition from ceramic to metal in well defined graded layers. While extensive research has been noted in this area worldwide, armor-related research has been limited. The primary application for armor technology is to solve the inherent difficulties of attaching ceramic/metal composites to armored vehicles without losing the high ballistic performance of armor ceramic composites or gaining large parasitic attachment mass which lowers relative system performance. Functionally gradient materials offer solutions for these problems as well as providing a composite material which has strong commercial potential. This topic area would allow the demonstration of this technology for use in near-term applique applications for upgrading the ballistic performance of the existing armored vehicle fleet.

Phase I: 1. Review the existing ceramic database and develop a matrix of ballistic ceramics which could be combined with titanium to form gradient materials. 2. Develop procedures or models to analyze the various material parameters that affect fabrication of functionally gradient materials such as thermal expansion, melting points and relationship to densification temperatures, elastic modules and other inherent material properties. 3. Select one or more representative ceramic/titanium composites and demonstrate the feasibility of the FGM by fabricating samples at least 100mm square or in diameter. 4. Propose the procedures for scaling FGM's to 150mm square tiles as well as further optimizing the FGM which would be used for Phase II ballistic testing. 5. Demonstrate the ability to mechanically attach the FGM to a metallic base armor.

Phase II: 1. Fabricate 150mm X 150mm tiles in various thicknesses to determine the baseline ballistic performance in standardized depth of penetration tests. 2. Optimize the ballistic performance by varying the interface compositions and thicknesses and fabricate improved ballistic tiles for testing. 3. Fabricate a large 450mm X 450mm array that can be mechanically attached to a base armor to demonstrate the multihit ballistic performance in a standardized ballistic test as well as the ability to adapt the design mechanically to a base armor.

Potential Commercial Market: The current commercial applications of functionally gradient materials of ceramic-titanium are large because the inherent metal base of the material is retained simplifying the mechanical/fabrication aspects of an application but allowing the high performance use of the ceramic facing. The materials have inherent high strength and net shape forming is also possible which reduces fabrication costs. Some applications include:

1.Improved machine tools with high fracture toughness which can be easily attached in fixtures.
2.High temperature aerospace components for improved wear resistance or for lightweight engine protective shroud materials.
3.Reduced weight automotive components such as brake linings or replacement of high wear components in the drivetrain.

TOPIC: A94-007TITLE:Nondestructive Evaluation of Advanced Composites and Composites Processing
Point of Contact: ARO

CATEGORY: Basic Research

OBJECTIVE: Develop nondestructive approaches for characterizing the integrity of polymer composites and/or diagnostics for monitoring the processing of advanced composites employing either positron annihilation or advanced laser diagnostic techniques.

DESCRIPTION: Develop and demonstrate nondestructive approaches for characterizing the integrity and/or diagnostics for monitoring the processing of advanced polymer-based composites using either positron annihilation or advanced laser diagnostics. Research is needed to provide real-time processing diagnostics and nondestructive evaluation of polymer-based composites. This program is directed at improving the reliability and lowering the costs associated with the manufacture and life-cycle use of advanced polymer composites.

Phase I: Identify potential characterization techniques and complete proof-of-concept experiments. A commercialization path should be outlined.

Phase II: Design, build, and operate a prototype characterization instrument. Explore major cost and applicability issues associated with commercialization of the system.

Potential Commercial Market: High performance polymer composites are expected to find broad commercial applicability to the auto and construction industries. This research will seek to provide low cost production and inspection techniques that will facilitate the commercialization of polymer-based composites

TOPIC: A94-008TITLE:Rapid Development of Complex Helicopter and Turbine Engine Components
Point of Contact: AVRDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop a design/manufacturing system which can rapidly generate a functional model of an aerodynamic or mechanical component which can be subjected to limited performance testing.

DESCRIPTION: Due to the complexity of modern weapons systems, the time and costs associated with their successful development and qualifications are rapidly becoming unaffordable. A revolutionary improvement in affordability could be realized if a prototype model of critical system components could be rapidly produced and subjected to proof testing. Furthermore, the ability to conduct early tests would allow many more iterations of a design to be conducted, thus improving reliability and allowing early incorporation/evaluation of maintainability features. The 3-D solid models available using stereolithography, currently the most popular rapid prototype method, have very poor strength, ductility, surface finish and dimensional stability over time. An advanced process or technique which significantly improves these deficiencies and provides high temperature (150-250 degrees F), strength and ductility is desired. Fabrication of the model from ceramic cast metals, powdered metals, high-strength engineering plastics would potentially improve some of these limitations. Processes which rapidly produce models using additive processes or advanced casting methods will be considered. It is desired that these models (scaled or full scale) be suitable for airflow, vibration, and potentially heat transfer and limited structural testing. For example, scale models of compressor rotors, gearbox housings and structural mounts for electronic sensors can currently be produced in less than ten hours using stereolithography. Due to the limitations of the model material and the relative accuracy versus the actual part, the model is unsuitable for testing. The ability to go from a solid model to a prototype, testable model in 3 to 5 days is desired.

Phase I: Develop a design for a rapid prototyping system capable of producing solid models suitable for limited functional testing. The system should be able to utilize geometric data from currently used computer aided design (solid modeling) systems. The system should produce models with strength, dimensional accuracy, and thermal stability significantly above those currently available utilizing stereolithography. The effect of process variations on

accuracy and stability shall be determined. Unique technical aspects of the system design should be demonstrated by bench testing. Results of this testing will be used to evaluate the concepts potential for successful development. Small gas turbine engine components such as cooled turbine blades, compressor rotors/blades along with aircraft structural components such as weapons an sensor installations and environmental control systems installations are or primary interest.

Phase II: A detailed design of the entire rapid prototyping system shall be conducted. A prototype of this system shall be fabricated. Gas turbine engine or airframe manufacturers shall be contacted to obtain trial part geometries. Several different trial parts shall be prototyped and subjected to functional testing. The ability of these tests to reproduce the component performance characteristics shall be evaluated. Potential Commercial Markets: If successful, the technology resulting from this topic would be applicable to a vast array of commercial products/markets. Companies producing aircraft, ground vehicles, gas turbines, internal combustion engines, electric motors, and many other commercial and residential products involving mechanisms and/or energy conversion would greatly benefit. All the major producers of the above products employ rapid prototyping systems to some degree in their current development activities. A system with the advantages to be developed by this topic would allow these companies to drastically reduce the time and cost of bringing new, high-quality products to market. A direct competitive advantage would be gained by companies utilizing this technology.

TOPIC: A94-009TITLE:Evaluation of Reinforced Elastomers as Erosion Resistant Coatings for Rotor Blades
Point of Contact: AVRDEC

CATEGORY: Exploratory Development

OBJECTIVE: Investigate an alternate approach in the design and development of material concepts that will combat the combined effects of wind and rain erosion on helicopter rotor blades.

DESCRIPTION: Rotor blade erosion has been a chronic problem for the Army and other services for many years. The problems associated with sand and rain impingement on blade leading edges and surfaces have resulted in severe damage and the resultant expenditures to replace, repair and maintain blades have been significant. The severity of the sand erosion problem was recently demonstrated in the Middle East during the Desert Shield/Desert Storm conflict.

An optimum erosion system for a rotor blade requires a design that is effective in both rain and sand environments. Testing performed to date shows that metallic (hard) erosion systems perform best in rain, and nonmetallic (soft/pliable) materials perform best in sand. An acceptable protective design compromise capable of extended performance in both sand and rain has yet to be fielded. In view that work directed toward solving this problem has been ongoing since early 1960 it appears that a new design approach, directed to achieve an optimum system, is warranted.

The elastomer (urethane, estane, etc.) stripping or boot applied to the rotor blade leading edge for sand protection lends itself, by its inherent physical characteristics, to modifications that will provide total erosion (sand and rain) protection. Metallic erosion protection systems, on the other hand, can only be enhanced by increased hardness and therefore do little to combat sand erosion.

This proposed effort will investigate the potential of enhanced rain erosion protection of elastomer matrices, already proven to have good sand erosion characteristics, by introducing fabric, fiber or mesh laminations to reinforce the elastomer and distribute the loads and deformations associated with rain impingement.

Phase I: The work to be conducted during this phase would use the analytical developments available from recent studies concerning the theories and mechanics of erosion on helicopter rotor blades and other aircraft systems to design and evaluate the integration of fiber and fabric reinforcement into elastomers already proven to have good sand erosion resistance. Reinforcement materials to be included in this study would include composites of varying denier, weave an d stiffness. Positioning (depth) of the reinforcement laminate within the elastomer, physical characteristics (durometer, thickness, etc.) of the elastomer on either side of the reinforcement laminate, and the use of multiple layers of reinforcement and elastomer will be addressed. A briefing describing the work conducted in this phase and

recommendations regarding material concept designs which should receive additional consideration (fabrication and test) will be provided. Upon Government approval test coupons representative of these designs will be fabricated and subjected to rain erosion tests. Results will be compared to previous work and ongoing tests conducted at the Wright Laboratory Rain Erosion Test Facility at Wright-Patterson AFB.

Phase II: Upon successful completion of the Phase I testing additional test specimens will be tested in a designated sand erosion test facility to assure that the addition of the reinforcement material has not sacrificed the original sand erosion resistance. Upon successful completion of the sand erosion tests, a manufacturing process development task will be undertaken to define possible full-scale fabrication techniques of the erosion resistant material concept. A full-scale set of prototype rotor blade erosion resistant tapes/boots will be fabricated for ground and flight test.

Potential Commercial Market: The results of this SBIR are applicable to both the helicopter and fixed wing commercial aviation industry. Erosion protection of wing leading edges and radomes are typical examples.

TOPIC: A94-010TITLE:In-Situ Composite Cure and Processing Transducers
Point of Contact: AVRDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop, characterize, and demonstrate inexpensive, durable, accurate sensors and transducers capable of monitoring, in-situ, the exact rheological state of a composite laminate throughout the entire injection (if appropriate), cure, and post cure inspection process. Sensors that can remain serviceable and useful in the cured structure, for use as a structural integrity monitor (damage, strain, etc.) are desirable.

DESCRIPTION: Currently, composite structural laminates are processed and cured based on idealized pressure and temperature profiles. Some attempts have been made to equip composite molds with acoustic, pressure, or temperature transducers, but these designs rely on extrapolation of surface condition data to estimate the rheological condition of the entire laminate. Sensors that are embedded into the laminates in critical areas, such as in thick areas and joints, that do not adversely affect the quality of the laminate will provide more accurate status for active or intelligent cure monitoring and control systems. Additionally, sensors that remain in the cured laminate may be valuable to assess the quality or integrity of the laminate for inspection purposes in production and in the field. Sensor development for directly measuring Tg, % cure, viscosity, etc., rather than using related parameters is desired. Development of in-situ sensors will support S&T Thrust #7 Technology for Affordability, and Structural Integrity Program objectives.

Phase I: Using the chosen sensor concept, define and quantify the appropriate thermoset, thermoplastic, or other polymer resin rheological parameters that are necessary to determine the exact state of cure of that system during processing and cure. Test and characterize the candidate sensor designs' sensitivity and accuracy in measuring the identified critical parameters. A final technical briefing summarizing the results and conclusions of the contract work will be presented to the Government at the Aviation Applied Technology Directorate, Fort Eustis, Virginia.

Phase II: Fabricate and test prototype sensors in-situ in composite laminates during optimum and anomalous cure cycles. Material characterization of the correctly cured laminates will be used to calibrate the sensors' performance. Interrupted, terminated, or otherwise anomalous cure cycles will be completed to demonstrate the sensors' ability to accurately diagnose the cure state of the laminate and monitor the remaining processing to achieve adequate structural integrity. Additionally, where appropriate, demonstrate the sensors' utility as an inspection (quality control) device or health (strain, damage) monitor.

Potential Commercial Market: Considerable cost allocations for composites fabrication are inspection, scrap, and rework due to anomalous cure cycles or inadequate inspection procedures. Inexpensive cure monitoring will allow cure cycles to be performed in the shortest, most efficient manner, and improve laminate qualities accordingly, thereby lowering the overall cost of composite structures fabrication.

TOPIC: A94-011TITLE:Advanced Materials for Attenuation of Low-Energy Laser Radiation
Point of Contact: NATICK

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate innovative materials and structures that utilize optical, electrical, or other mechanisms to reduce the intensity of laser beams to a safe level, in a manner that causes no more than insignificant interruption of the normal functioning of the eye or other light-sensing device.

DESCRIPTION: Numerous laser devices are found in the armed forces of all nations, and unknown numbers of such devices are found in various insurgent and independent armies. The eyes of the soldier, and the many sensors essential to the combat effectiveness of our fighting forces concentrate the energy from these low-energy devices. The resulting high concentration of laser energy is capable of damaging the retina or the sensor. Protective devices thus far developed, utilizing fixed filters of some type, provide a useful but limited level of protection against one, two or three laser wavelengths, usually with a significant loss of vision caused by reduction in the overall level of light transmitted.

Phase I: Investigate new materials and structures that interrupt or attenuate low-energy laser beams from devices operating at one or more wavelengths, reducing the residual energy to a level that causes negligible damage to the retina or sensor. Structures that have shown some promise in the past include rugate filters and non-planar holographic structures for several fixed wavelengths, as well as nonlinear optical materials and lens arrays for tunable lasers. Each of these has shortcomings. In the first phase of the proposed SBIR, a specific approach to laser eye protection is to be developed, and a demonstration device incorporating the approach is to be built. The device should have a visual transmittance of at least 50% in its normal or unactivated state. An effective optical density of 4 throughout the designated spectral region should be attained within 30 nanoseconds of the initiation of the laser pulse.

Phase II: The concepts developed in Phase I should be incorporated into a complete system of headborne eye wear providing the specified level of laser protection. The device should be as lightweight and compact as is feasible, and should exhibit maximum durability with available materials.

Potential Commercial Market: Lasers, and devices using them, are becoming commonplace in several commercial applications. For example, the use of lasers in surgical procedures calls for protection against the laser wavelength with maximum transmission of all other visible light. In laboratories where several types of lasers are in use, efficient blocking of multiple wavelengths may be required. In this case, the requirement for a high level of light transmission is even more difficult to meet. The technology developed under this SBIR should be applicable to these and other commercial uses.

TOPIC: A94-012TITLE:New Helmet Materials for Increased Ballistic Protection
Point of Contact: NATICK

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate an improved lightweight material system with increased protection against multiple ballistic threats for helmet application.

DESCRIPTION: Current helmets fielded for Army use are designed to provide a high level of protection against fragmentation-type threats. However, as the world scenario changes, the ballistic protection offered to the individual soldier must adapt to the changing threats. Certain Army elements already are looking to upgrade protective requirements and are suffering the penalties associated with standard materials. The objective of this effort is to investigate combinations of new and/or existing materials technologies for potential application in helmets that will

maintain current levels of fragmentation protection, and without substantial weight penalties, increase the performance against other ballistic threats, such as small arms rounds. The overall goal of this effort will be to improve the capability of the soldier (endurance, survivability, mobility and lethality) though the development of an optimized materials system for maximized ballistic performance against multiple ballistic threats.

Phase I: Identify and explore novel concepts with potential for meeting ballistic performance and weight requirements. Design and develop a "breadboard" system and prove feasibility of material system through laboratory tests including ballistic evaluation.

Phase II: Optimize selected Phase I system and demonstrate weight and fragmentation resistance comparable to Personnel Armor System for Ground Troops helmet with increased protection against small arms (.30 caliber) projectiles. Produce prototype helmets for delivery to government for full ballistic and durability evaluation. Provide final technical report will full specification for optimized system(s).

Potential Commercial Market: This technology will be directly applicable to the law enforcement armor industry.

TOPIC: A94-013TITLE:Development of Flexible Materials System for Small Arms Defeat
Point of Contact: NATICK

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate a flexible material system or materials application configuration for body armor designed to protect against multiple ballistic threats including fragments and small army ammunition.

DESCRIPTION: Along with weight and bulk, flexibility is a key consideration in user acceptability of body armor items. Research and development efforts are ongoing to develop lightweight materials systems that provide a high level of ballistic protection against multiple ballistic threats. Flexibility is typically inherent in the materials used to protect the individual soldier from fragmentation-type threats. A configuration has also been developed and demonstrated that allows for a flexible application of the rigid-composite materials required to defeat flechettes. The ceramic- and metal-based composites currently used to protect against small arms threats (.30 caliber) present technical barriers (e.g., physical structure, thickness, failure mechanisms) that inhibit their application in a flexible manner. Significant advancements are necessary to accomplish the development of a flexible system that maintains acceptable performance against small arms threats without adversely impacting the overall weight of a system. Potentially, there are at least two approaches to addressing this problem: 1) the development of a new lightweight material system that is inherently flexible, or 2) the development of a method or technique to apply current or emerging rigid materials in a flexible configuration without compromising performance or weight. The first approach is considered to be the most technically challenging since data to date supports the need for a rigid materials to defeat these kinetic energy rounds.

Phase I: Identify and explore novel concepts with potential for meeting objective. Design and develop a "breadboard" system and prove feasibility of technique in laboratory tests including ballistic evaluations.

Phase II: Produce and optimize selected system(s). Complete full evaluation and provide final technical report with full specification for optimized system(s).

Potential Commercial Market: This technology will be directly applicable to the law enforcement body armor industry.

TOPIC: A94-014TITLE:Flexible Bulk High Temperature Superconductive (HTS) Material with High Critical Current and High Critical Power Handling Capability
Point of Contact: CECOM

CATEGORY: Advanced Development

OBJECTIVE: To improve the electrical characteristics of the newly-developed flexible bulk superconductors to enable them to work in the high frequency A.C. and high power and current regimes.

DESCRIPTION: The family of modern high temperature (T > 77K) superconductors is made of copper oxides of Yttrium, Lanthanum or Bismuth. They make possible myriads of applications in military and commercial electronics applications. At the present tim e their shape constrains their usefulness. Bulk Yttrium, in particular, can only be manufactured into straight segments while retaining its extraordinary electrical properties. Bismuth's crystal morphology on the other hand, allows considerable bending of the bulk wire, but taxes in current density and frequency. The industrial sector is invited to continue its research and exploratory development in order to produce a superconducting material capable of being warped or bent, so it can be applied to various communications electronics components requiring selected three dimensional geometries and sizes. Phase I: This phase shall establish a proof of concept that flexible superconductive bulk wire can be made, especially to be formed into a helical shape.

Phase II: If a feasible approach is determined, develop and demonstrate a prototype model using this hardware.

Potential Commercial Market: The entire communications industry, general electronics industry and even most of the high power applications will benefit immediately from this innovation. The demand for more complex type superconductor is spiralling up.

TOPIC: A94-015TITLE:Advantages of Sol-Gel Glass Technology for Processing 100% Silica Optical Fiber Waveguides

Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: To develop a process for the manufacture of optical glass fiber, and more specifically relates to a novel process in which glass precursor coatings are formed on a continuously moving filamentary core of material which is removed from or become s an integral part of the ultimately formed optical fiber.

DESCRIPTION: Conventional preforms require complicated processing steps and repeated batch-type handling and increase the cost of the ultimate fiber. Thus, the preform may constitute 75% of the cost of the fiber. Furthermore, since fiber is drawn from a r od of given volume, the length of the fiber which can be drawn is limited. This increases the number of optical couplers and amplifiers needed to connect a number of relatively short segments into a very long signal path. An optical fiber shall be formed by continuously coating a precursor core filament with a glass-forming coating. The precursor's volatile host shall be continuously processed to convert the coating to a glass, with the core either removed from the fiber during glass forming or becoming an integral part of the ultimate fiber during glass forming. The glass fiber shall be densified in a continuous process. The fiber shall be provided with a protective coating as it moves through a stationary coating station and the completed optical fiber is continuously reeled.

Phase I: A thorough investigation of the state of the art processing for volatile organic fibers or filaments that will allow for sol-gel glass coating to be vitrified onto a volatile host into an optical silica glass fiber having the low optical loss and high mechanical (tensile strength) equivalent to its conventional fiberizable glass preform.

Phase I: Will continue on-going R&D efforts of phase I aimed toward the production and commercialization of low cost optical glass fiber.

Potential Commercial Market: This process shall eliminate the expensive fiberizable glass preforms used in military and commercial applications for communication systems. It will also utilize domestic U.S. materials for processing a non-preform fiber which currently depends on foreign sources.

TOPIC: A94-016TITLE:Non-Toxic Self Lubricating Materials for Automotive Applications
Point of Contact: TACOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop non-toxic, environmentally compatible, self-lubricating materials for automotive components.

DESCRIPTION: The use of hazardous materials like lead in automotive components is an increasing cause for concern due to the cumbersome methods and costs associated with the disposal and handling of these components. New materials that are non-toxic and environmentally safe are desired. The materials must be readily available, inexpensive and easy to manufacture into complicated shapes without sacrificing the lubrication capabilities.

Phase I: Develop techniques for producing self lubricating materials for use in automotive applications. Perform limited life cycle tests and conduct cost comparisons with existing materials.

Phase II: Produce sufficient quantities of materials needed for fabrication and testing of components; perform engine bench tests; conduct limited tests of components on fielded vehicles; and, evaluate component performance and costs.

Potential Commercial Market: Environmentally compatible, self lubricating materials have numerous uses in bearings, bushing, sleeves and other moving mechanical assemblies in the automotive, machine tool and aerospace industries.

A-2MICRO/ELECTRONICS AND PHOTONICS

TOPIC: A94-017TITLE:Components for Optical Control of Millimeter Wave Systems
Point of Contact: E&PSD

CATEGORY: Exploratory Development

OBJECTIVE: Development of key components for optical linking and control of advanced millimeter-wave systems for future Army radar and communication applications.

DESCRIPTION: Future Army requirements for the digital battlefield, mounted battle lab and communications on the move will require the use of optical fiber connecting links between a central processor and remote amplifiers and antennas. In various system designs these links may carry a transmitted or received radio frequency signal, a down-converted signal, a reference signal, or a control signal. The millimeter-wave frequency range of interest is 35 to 100 GHz. One example of such a system using optical links would be a phased array radar where individual amplifiers located at the antenna elements receive their rf exciting signal through a fiber link. Key components for such systems include modulators (either direct or external modulation of lasers), detectors, low loss switching networks, and optically controlled amplifiers. Innovative device concepts and techniques in these areas are sought. New millimeter wave optical devices must possess excellent stability and be capable of operation over the Army environment range. Chip level integration of millimeter and photonic devices is the ultimate goal.

Phase I: Develop a selected device concept through analysis of expected fabrication techniques and device performance. At the end of Phase I a report of device design, simulated performance, and expected fabrication process should be delivered to the government.

Phase II: Fabricate and test the devices developed in Phase I. The fabrication processes developed in this phase should be compatible with MMIC processing. Devices for testing by the government will be provided throughout this phase.

Potential Commercial Market: Civilian applications include phased array antenna systems for satellite based communications, aircraft radar systems, and automotive collision avoidance radars.

TOPIC: A94-018TITLE:Hybrid Diffractive-Refractive Optical Elements
Point of Contact: S3I

CATEGORY: Basic Research

OBJECTIVE: In this Phase I effort, new design techniques for hybrid diffractive/reflective lenses will be investigated that can improve image quality, diffraction efficiency, and performance over wavelength.

DESCRIPTION: Diffractive Optical Elements (DOEs) are useful in performing a number optical processing functions such as array generation in image morphology and as filters for pattern recognition. In combination with refractive elements, diffractive optic al elements can be useful in packaging to reduce weight, improve image quality, and extend performance over wide temperatures.

Phase I: In the Phase I study, novel design techniques which combine the properties of refractive and diffractive elements will be proposed and investigated. Investigation will consider optical performance and manufacturability. A final report will be generated which describes the results and the likelihood of success in Phase II.

Phase II: Upon successful completion of the Phase I objectives, prototype elements will be fabricated and tested in Phase II.

Potential Commercial Market: DOEs can be useful in a variety of military and commercial applications. In the commercial sector, DOE's are useful in optical data storage, optical interconnects, and interocular lenses. In military systems DOE's can be used in optical processing, infrared imaging, and helmet- mounted displays.

TOPIC: A94-019TITLE:Programmable Microwave Fiber-Optic Delay Line Network
Point of Contact: SLAD

CATEGORY: Exploratory Development

OBJECTIVE: Research and develop a fiber optic delay line network capable of providing a digitally programmable delay of wideband microwave signals.

DESCRIPTION: Current microwave delay line technologies based on bulk wave devices, surface acoustic wave devices and digital RF memory (DRFM) systems have performance limitations that render them unsuitable for wideband microwave signal processing and other applications. Fiber optic technology offers a viable alternative with the potential for greatly improved system performance along with reduced complexity, size and cost. The objective of this effort would be to research, develop and deliver a prototype microwave delay line system utilizing fiber optic technology with the following technical goals:

1. Signal bandwidth: > 16 GHz
2. Signal dynamic range (noise floor to input 1 db compression: > 40 db
3. System gain: 0 db +/- 1.5 db over Signal Bandwidth
4. Delay variability: 0 to 655.34 microseconds, digitally programmable in steps of 20 nanoseconds
5. Delay switching speed: < 1 microsecond for any delay change
6. Minimum throughput delay: < 20 ns
7. Spurious products including triple transit response: -35 dbc or lower
8. Operating temperature range: 0 to +50 C
9. Delay variation over operating temperature range: < 1 nanosecond

10. Reduced size, power requirements and cost compared to DRFM technology

Phase I: Research, develop and propose a system design with the potential of realizing the goals in the description above, favoring proven technologies to minimize technical risk. Develop technical specifications for all system components and identify them as commercially available or to be developed. Model and predict the performance of the proposed system, identifying critical components to be developed. Conduct detailed theoretical and laboratory investigations on the design and performance of critical components to demonstrate the feasibility and practicality of the proposed system design. Deliver a report documenting the research and development effort along with a description of the proposed system and specifications for all system components.

Phase II: Procure or develop the system components specified in Phase I. Fabricate the prototype microwave delay line system as proposed in Phase I. Characterize and refine the system performance in accordance with the goals stated in the description above. Deliver the prototype system along with a report documenting the system theory, design, component specifications, performance characterization and recommendations for system refinements.

Potential Commercial Market: Technologies exploited and advanced by this effort include wideband microwave modulation and demodulation of laser light, high speed optical path switching, and the development of low loss delay techniques for wideband microwave signals. All of these technologies have extremely wide commercial application to the development of wideband computer local area networks, telecommunications systems and microwave signal processing for spread spectrum communication and radar systems.

TOPIC: A94-020TITLE:Optical Fiber Coupled Integrated High-Low Energy Laser
Point of Contact: WTD

CATEGORY: Exploratory Development

OBJECTIVE: Development of an integrated laser system which can deliver both intense high energy laser pulses and low energy high-peak power laser pulses from the same device. The single unit will be controlled with a microprocessor.

DESCRIPTION: A dual purpose optical fiber coupled integrated high-low energy laser is desirable. A small modular laser system which can generate intense high energy laser pulses capable of igniting energetic solid and liquid propellants, welding and cutting metals such as titanium and used in industrial materials processing differs from a low energy system which can be used for optical communications. A single laser system which can operate in both regimes to produce 5 millisecond, 20 Joule laser pulses (such as from a Nd:YAG) or millijoule infrared laser pulses (such as from a diode laser) is required.

Phase I: Design dual purpose hybrid laser system. Bench top construction of proof-of-principle system desirable.

Phase II: Electronic circuit design, integrate high energy and low energy laser technology to fabricate compact system.

Potential Commercial Market: The system will have excellent commercial market applications in the areas of telecommunications, industrial in-process control, laser welding, laser marking and writing, laser surgery, laser dentistry, etc. The system can also be used for commercial blasting applications (mining, demolition), programmed initiation; all electrical connections to high explosives eliminated by replacing wires with glass optical fibers, which are invulnerable to stray electromagnetic fields. Wires often break. Low energy laser pulse can be used to verify integrity of fiber prior to high energy pulse which is used for initiation. Optical fiber probe and low energy laser pulse can be used to locate blockages in arteries, high energy laser pulse can be used to remove blockage. Commercial applications also include laser pyro-actuated rescue equipment such as the "Jaws-of-Life" which are being designed to use a laser initiated pyrotechnic charge in place of the hydraulic lines. Military applications include laser igniters for large caliber guns (Regenerative Liquid Propellant Gun, Unicharge), Rocket Motor ignition (MICOM RELEVANCE) and high

explosives initiation.

TOPIC: A94-021TITLE:Advanced Thermoelectric Materials for Refrigeration and Cryogenic Cooling Systems
Point of Contact: ARO

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate new and innovative thermoelectric materials for use in refrigeration and cryogenic cooling systems. This program is directed at vastly improving the efficiencies of existing thermoelectric cooling systems and providing an alternative technology which can eliminate the environmental problems associated with the atmospheric release of the chlorofluorocarbons (CFC's) currently used in all conventional refrigerant and cooling systems.

DESCRIPTION: Develop new thermoelectric materials with figures of merit (ZT) roughly 7x greater than the present state-of-the-art materials for utilization in advanced refrigeration systems. To accomplish this objective, innovative new approaches to materials development will be required. One possible approach is to adapt superlattice concepts already utilized in semiconductor microelectronics to the field of thermoelectrics. The approach affords the potential for bandgap engineering and delta doping of thermoelectric superlattice structures to vastly improve on electronic carrier mobilities. At the same time the superlattice structure should degrade the lattice thermal conductivity of the material system by increasing phonon scattering from the added interfaces and differing atomic masses. This combination of higher electronic and lower thermal conductivities directly translates into potentially large gains in the overall thermoelectric performance. Such an effort would lead to the development of new materials with large potential ZT enhancements. This would provide efficient thermoelectric coolers to temperatures below 100K for cryogenic sensor and electronic applications, and would permit the direct substitution of all current CFC-based air conditioning and refrigeration technologies by thermoelectric cooler systems with plug compatible efficiencies. Phase I: Investigate innovative approaches to obtaining advanced thermoelectric materials with figures of merit (ZT) roughly 7x greater than the present state-of-the-art materials.

Phase II: Implement the new materials into a thermoelectric cooler. Design and test a prototype system. Explore major cost and reliability issues associated with producing a material suitable for construction of a commercially viable cooling unit.

Potential Commercial Market: This technology would have immediate application to the commercial air conditioning and refrigeration industry. It would also make feasible cryogenic electronics and computing, affording new opportunities for implementing device concepts based on superconductivity and other low temperature phenomena.

TOPIC: A94-022TITLE:Multisensor Inspection for Microelectronics
Point of Contact: MICOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop techniques for sensor fusion between multiple inspection methods for subminiature electronic

DESCRIPTION: A number of inspection techniques exist for inspecting electronic assemblies such as printed wiring boards and multi-chip modules. These include x-ray, infrared, ultrasonic, and 3-D 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 required for fusing image data from multiple inspection methods in essence to increase the signal-to-noise ratio in the data. This should increase the probability of finding defects, reduce the incidence of false alarms, and possibly allow 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: Phase II would consist of preparation of detailed design drawings, collection of data from proposed individual inspection systems, development of pseudocode to implement algorithms, and assembly of a prototype system. Prototype design will be verified by inspecting example electronic assemblies.

Potential Commercial Market: The technology proposed is widely applicable to commercial electronic inspection requirements. The computer, telecommunications, and consumer product industries depend heavily on state-of-the-art microelectronics to remain competitive in these highly contentious areas. Their requirements for high-density interconnect inspection are just as demanding as those for military weapons systems. Assuring the quality of the interconnects between these increasingly micro-scale components and the substrates that carry their signals to other components and the outside world will be next to impossible using current single-sensor and visual techniques.

TOPIC: A94-023TITLE:Computational Vision Models for Virtual Reality and Photo Realism Applications
Point of Contact: TACOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop high fidelity, high resolution, color imagery for interactive training devices including target acquisition simulators and other virtual reality applications.

DESCRIPTION: Computational vision models of human perception are uniquely suited in determining the optimal scene content necessary for performing various visual performance tasks. Virtual reality simulations need some performance measures which determine the optimal configuration of various cue features important for object detection and recognition. Interactive training devices, for example, such as flight, driving, and target acquisition simulators need to challenge the human participants at the limit of t heir capabilities in order to avoid making the task either too difficult or easy. The devices need to adapt to individual subject performance by enhancing or reducing conspicuity of critical scene features and background clutter, while retaining the overall realism of the original imagery. Computation vision models are uniquely suited to this task because they predict human performance based upon first principle models of human perception. Performance is directly formulated in terms of individual channel signal to noise characteristics in order to prioritize cue features for specific tasks.

Phase I: Demonstrate software feasibility on a Silicon Graphics Workstation using a computational vision model of human perception. The demonstration should incorporate full color, high spatial and temporal resolution scene features and apply specifically to target acquisition applications.

Phase II: Design and build a full scale hardware implementation of the computational vision model which uses conventional off the shelf computer graphics workstations. Demonstrate the applicability of the software to several virtual reality applications including driving, automotive conspicuity, and higher level object discrimination.

Potential Commercial Market: The Computational Vision Models of early vision have many dual use commercial applications including photo realism and virtual reality, photo interpretation, machine vision, conspicuity analysis for collision avoidance and automotive driving simulation.

TOPIC: A94-024TITLE:Real Time Wavelet Transforms for Pattern Recognition Applications
Point of Contact: TACOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop a real time wavelet transform processor for the analysis of spatial and temporal signals.

DESCRIPTION: Wavelet transforms can adaptively filter position-varying spectra for local spectral information. The resulting frequency decomposition is particularly appropriate for pattern recognition and texture segmentation of 1-D signals and 2-D imagery. The adaptive window size allows the wavelet transform to zoom on discontinuities, edges and other types of cue features where an optimal combination of local amplitude and phase information is essential for a high fidelity temporal and spatial representation. The constant Q property of wavelet band pass filters leads to a sampling in the scale dimension which is exponential and can be implemented with fast algorithms. A discrete signal decomposition into a complete, orthogonal set of wavelet basis functions is very useful for characterizing general signals using a very small number of wavelet coefficients. A software configuration should include a performance measure (i.e., entropy) for an optimal segmentation of Heisenberg phase into individual signal cue features using conventional wavelet transform implementations.

Phase I: Demonstrate software feasibility of 1-D and 2-D real time wavelet transforms using a Silicon Graphics Work Station. The demonstration should incorporate 1-D acoustic signals and 2-D visual and thermal imagery of Army ground vehicle systems. Evaluate the feasibility of a real time processor for a phase 2 effort.

Phase II: Design and build a full scale hardware implementation of a real time wavelet transform processor which uses conventional off the shelf computer graphics workstations. Demonstrate the applicability of the hardware and software configuration to several commercial and military signal processing applications.

Potential Commercial Market: Wavelet analysis has many dual use applications relating to acoustic analysis for commercial sound applications, seismic analysis for oil exploration, image compression for high density TV, and object recognition.

TOPIC: A94-025TITLE:Simplified Environment for Insertion and Extrapolation of Low Observable Material Signatures into Photo-Realistic Imagery
Point of Contact: TACOM

CATEGORY: Exploratory Development

OBJECTIVE: Tradeoffs of various signature management materials reflectance characteristics can be difficult due to the complexity to the spectral reflectance and bi-directional reflectance when put into the open environment. A simplified technique is required to make these tradeoffs without completing a full parametric evaluation with large signature models for all environmental conditions.

DESCRIPTION: The visual thru thermal bands, .4-14 microns, is a large span of wavelengths to balance signature management materials spectral reflectance to match a specific background. Surfaces can be described in terms of diffuse and specular reflectance. When materials applied to ground vehicle systems in the open environment, specular reflections play an important role in the overall signature of the vehicle. By tailoring the materials applied the surface may be more or less specular. The bi-directional reflectance is also an important quantity to accurately represent a surface. The reason is that the sky is not uniformally luminated. So at various angles to which a vehicle is viewed the energy received at the eye/sensor is a combination of the integrated sky convolved for each vehicle facet, for each sky angle. In some cases an additional term of the foreground must be included in the calculations.

Phase I: Develop a technique to model narrow band spectral and bi-directional reflectance. Combining this model with environmental effects such as sun, sky and foreground. Calibrate the model with environmental examples for each spectral band.

Phase II: Implement the basic model to handle full vehicle common geometry including FRED facet, IGES128 and IGES114 entities. Include detailed spectral calibrated sky and ground model.

Potential Commercial Market: This technology would have application to building design for a total solar energy passive solutions. Tradeoffs must be made with respect to chromaticity, thermal absorbitivity for pointed surfaces as well as coating for glass surfaces.

A-3SENSORS AND INFORMATION PROCESSING
(I.E. COMMUNICATIONS)

TOPIC: A94-026TITLE:Scanning Linear X-ray Tube
Point of Contact: ARDEC

CATEGORY: Advanced Development

OBJECTIVE: Develop a family of x-ray tubes in which the electron target is long and narrow.

DESCRIPTION: Standard x-ray tubes use a point electron target with x- rays with x-rays emitted at some angle from

the normal to the electron target. DIGIRAY builds an x-ray tube whose target is the face of a CRT with x-rays emitted forward from the face of the CRT in a raster scan fashion. IMATRON builds an x-ray tube whose target is a large arc supporting medical tomography. This solicitation is for the development of a family of x-ray tubes in which the target would be a long straight line and scanned in linear fashion, similar to the IMATRON tube. The family should include tubes that have electron targets of various lengths, ranging from about ten centimeters to one meter or more. The scanning of the target, beam current and accelerating voltage of the tubes must be electronically controllable from a microcomputer. Scanning rates should be greater than sixty scans per second. The range of accelerating voltage should be from 20 KeV to 180 KeV and higher. Tube currents within the family should range from one milliampere to several hundred milliampere . The effective spot size of the x-ray beam must be as small as possible and always less than two millimeters and preferably comparable to that of microfocus tubes. Some of the tubes must be designed such that the x-rays will be emitted perpendicular or nearly perpendicular to the plane of the electron beam. The x-ray window of the tube and its surroundings must be formed close to the electron target to facilitate placing the source near the object to be x-rayed.

Phase I: Create and deliver detailed designs for x-ray tubes in the family from which any contractor skilled in tube manufacture could build the tubes. The design must be based on proven in-use x-ray tube designs. Demonstrate that the designs will meet top level requirements, preferably by building a simple prototype tube.

Phase II: Develop, construct, test and deliver several working prototype tubes that span the design specifications created in Phase I.

Potential Commercial Market: The x-ray tubes can be utilized for computed tomography applications in industrial radiography, in the medical field, and in inspection of crated items and luggage.

OSCR: The technology will provide the Army an important missing component of a computer tomography inspection system now being designed and to be used for inspection of crated supplies while in storage, prior to shipment, or upon receiving. The current process for inspection of crated items requires the crates be opened and resealed. For certain items opening, handling, and resealing can be a safety problem and can damage the items. For certain items this process must be done in a special conditioned atmosphere, etc. In most cases, the current process is much more expensive than will be with the computer tomography system being developed. Frequently, because of the inspection cost the contents of crates are not inspected at all. Using the linear x-ray tube will make it possible to inspect the contents of crates of nearly any size without opening the crates, at conveyor belt speeds, without human supervision.

TOPIC: A94-027TITLE:Digital Howitzer Sight
Point of Contact: ARDEC

CATEGORY: Engineering Development

OBJECTIVE: Develop an integrated sighting system for self-propelled and towed howitzers consisting of an autoleveling mount, a directional and vertical reference, a digital interface for input of fire commands, and an output display for use in positioning the weapon by the gunner.

DESCRIPTION: The present fire control sights on U.S. howitzers are optical instruments that require manual leveling, manual input of fire commands, an optical reference to a collimator to determine weapon traverse, and reference to a bubble vial for weapon elevation. This manual operation requires significant operator skill to accomplish in an accurate and timely manner, and requires additional verification to preclude accidentally firing on friendly units. As the Army moves to an increasingly digitized battlefield, this present manual artillery fire control sight will be the limiting element in the requirement to conduct responsive, effective, and safe fire support. T he essential characteristics of the fire control sight to meet this requirement are:

a) Configuration as a retrofit item so that it can be applied to existing towed and self-propelled howitzers with minimal or no modification to the existing weapon. It could also be used as a part of some future artillery fire control systems.

b) The ability to automatically level the optical element of the sight by replacing the manual levelling using bubble vials of the present sight mount.

c) The optical element (panoramic telescope) should be rugged and light weight, constructed of state-of-the-art optical technology. It should also function as the direct fire sight for targets out to ranges of 2000 meters.

d) The sight should have a directional reference which will determine the orientation of the gun tube with respect to a grid north reference when the gun is initially layed upon occupation of the firing position. The required accuracy is one artillery m il with a required time to orient of 180 sec and a desired time of 120 sec. This directional reference will also function as the reference for subsequent traverse of the gun tube. The reference may be integral with the sight or a separate unit mounted elsewhere on the weapon with an electrical/electronic interface to the sight. The optical element is also to be referenced to this directional reference.

e) The sight should have an electronic horizontal reference integral to the sight. This reference would function as the reference to elevate the gun, to level the optical element, and to position the optical element for direct fire.

f) The sight should electronically accept fire commands in digital format either in standard RS-422 computer format or in the present gun display unit format.

g) The sight should output to a suitable display for the gunner, the direction and the amount to elevate or depress the gun and to traverse the gun so that the gun is pointed in accordance with the given fire commands. The optical element should also move in such a manner that the reference direction is maintained. The sight should output a digital signal which confirms tot eh source of the fire commands that the gun has been correctly positioned in elevation and traverse.

h) The sight should provide for one man, one sight aiming of the howitzer. An auxiliary display for elevation only may be required for the assistant gunner to allow for two man operation on some weapons.

Phase I: Develop a conceptual design for the digital sight including appropriate trade-off analysis to define the significant features and the specifications for the components. Do an error analysis to determine the required accuracy of the azimuth and elevation references and any other components which impact the overall performance of the sight. Develop a preliminary design for the optical element. Complete a preliminary functional specification and a plan of r development of four prototype units in Phase II.

Phase II: Develop four prototype digital sights for engineering test and field evaluation. Initial testing will consist of engineering tests in the laboratory and in the field to validate the design concepts and to verify the sight's operability during live firing. Subsequent testing will extend to a firing platoon (four guns) and will expose the digital sight to a user field evaluation. Based on the analysis of data from the tests and the demonstrated accuracy and functional characteristics, develop a finalized functional specification for the digital sight.

Potential Commercial Market: The technology developed under this program would have broad application int he ares of civil engineering, environmental and other disciplines where accurate orientation of a device with respect to external references is required. Any robotic device which must accurately position itself to perform a task while maintaining a relationship to a directional or horizontal reference would be a specific application of this technology. The commercial market potential for this technology, packaged in a different form, is extensive and would definitely support follow-on development.

OSCR: This digital sight would increase the responsiveness and accuracy, and improve the safety of existing U.S. Army howitzer weapons, both self-propelled and towed. All weapons, except those of the M109 family, converted to Paladin configuration would benefit from its development and production. It would be possible to retrofit existing weapons with minimum cost. The digital sight wold be compatible with the existing TACFIRE system and the future AFATDS and digital battlefield without modification. The system would be lighter and easier to manufacture

than present optical sights and mounts and would include inherent alignment verification and backup capability lacking in other all electronic howitzer fire control systems.

TOPIC: A94-028TITLE:Computer Aided Software Testing for Reusable Ada Software Components
Point of Contact: AC&ISD

CATEGORY: Exploratory Development

OBJECTIVE: Develop concepts and software tools that can reduce the amount of testing required on a reusable software component (from a reuse repository) when it is reused is another environment. Software reliability must be measurable in the new environment with a minimum amount of testing. The goal is to reduce the amount of testing necessary to reuse a software component in another application.

DESCRIPTION: The Army (and DOD) could benefit from an automated software testing tool for Ada components that can capture, store, and retrieve internal data state information. This information might then be used to reduce the time required in re-testing the component when reused. Like hardware, reusable software components are seen as a way of increasing software reliability. Reusable hardware components allow one to quickly replace faulty hardware. This has greatly increased the reliability and reduces the down-time of hardware systems. It is hoped that software reuse can result in similar improvements for software systems. Object-oriented languages and libraries of mathematical and scientific procedures are outgrowths of this desire to reliably reuse software. When a software component form one application can be reused reliably in another application, software development time is decreased and programmer productivity is increased. A proposed approach is to develop a technique to verify the software component by collecting information on the data states during its initial testing. By collecting this information, along with the output produced by that data state, one is able to stop the testing whenever a data state created is identical to one already collected during the initial testing. This is possible because for this test case we already know the outcome. This technique will help to reduce the development time and costs when using reusable software components.

Phase I: This phase would study various methods to efficiently capture, store, and retrieve the internal data state information to reduce the time required in re-testing the component. Measures, such as testability, would be applied to determine where, and how to best apply the techniques to software components. A final technical report would document the work and suggest appropriate implementation strategies.

Phase II: Phase II would design, prototype, and demonstrate the tool on actual Ada software components.

Phase III: This phase would validate and commercialize the prototype by experimenting on actual Ada software components in a repository and their reuse in practice. The contractor would provide evidence of the advantages of using this technique. Deliverables would minimally include the software and documentation, and final technical reports summarizing all experimental evidence collected, research findings, and an overall evaluation of this technique in terms of applicability to real world reuse activities.

Potential Commercial Market: Dual use potential is excellent. Private sector firms that are using Ada have the same need to reduce the cost of testing software. Potentially, 100% of the technology developed in this research will be pertinent to non-government agencies.

TOPIC: A94-029Title:Video Compression Routines
Point of Contact: AC&ISD

CATEGORY: Exploratory Development

OBJECTIVE: Develop fast compression and playback routines for full screen, full motion, color video with sound.

DESCRIPTION: Army mechanics are being issued computers to help them diagnose and repair faults. The computer, called the Contact Test Set (CTS) III, is a 486 laptop running under Microsoft Windows 3.1. The Army Research Lab is working with the Ordnance School to develop diagnostic software for the M1 turbine engine. This software runs on the CTS III and will replace existing paper manuals for the engine. The need for sound and video capability has been demonstrated at recent field tests where soldiers were asked to diagnose engine problems using the CTS III.

Phase I: Survey existing standards for audio and video compression and playback are suitable for use on the CTS III. Identify potential new routines and techniques. Compression routines should handle 24 bit color video with 16 bit synchronized audio sampled at 22KHz. Playback speeds should approach 30 frames per second on the target architecture. Compression ratios should store several minutes of synchronized video and audio in 1 MB. Playback routines should be Windows 3.1 compatible. Identify any hardware upgrades associates with playback routines.

Phase II: Development of a prototype compression and playback system based on the results of Phase I. Provide estimates of compression ratios and playback speeds. Demonstrate system using Army provided samples. Provide system documentation.

Potential Commercial Market: The PC multimedia market is huge.

TOPIC: A94-030TITLE:Comprehensive Array Design System for Printed-Circuit Antennas
Point of Contact: ARO

CATEGORY: Basic Research

OBJECTIVE: To develop computer aided design (CAD) which will be capable of one iteration design of printed antenna and antenna array systems. The purpose is to enhance the current design process and to facilitate novel design of printed antennas embedded in the complex environment uniquely found in the Army battlefield environment.

DESCRIPTION: Studies continue to show that, the radiating system of portable Army electronic systems become a dominant factor in the attainment of compact, reliable systems with optional power performance. As power requirements for digital processing electronics continues to dramatically decline, analog RF components and systems become the major user of primary battery power. Because of fundamental limitations, as expressed in the "Friis" equation, gain related to the efficient and perhaps self-adapting antenna system remains an area where system improvement can be achieved. This gain improvement impacts battery weight requirements with almost a linear factor for modern communications systems (e.g. doubling the antenna system gain will reduce the battery weight by almost a factor of two). Printed antenna are light weight, small in size, inexpensive to produce, conformal to complex surfaces and highly efficient. Despite the fact that they are easy to produce, progression realizing the full potential has been slow due to difficulties in modifying or tuning designs once they have been fabricated. Without adequate analysis / diagnostic tools, antenna designers simply cannot afford to apply these antennas in complex environments, nor can they afford to explore novel concepts. The concept of a comprehensive array design system for printed circuit antennas and arrays, including the feed network must be developed. To provide an all-encompassing design environment, the design system must have the capability to perform array synthesis, to simulate aperture as well as patch antennas in a multi-layered configuration, to design feed networks, to analyze layouts and to perform sensitivity analysis of the resulting radiating system. All of these capabilities must be integrated seamlessly int o a common design framework. To develop a comprehensive array design system involves not only the development of new simulation programs, but also a user friendly graphical interface. Most rigorous numerical programs for antennas are non-trivial because to use they require not only specifying the boundary of the geometer but also discretizing the array structure geometer into cells as well. This is especially true for sensitivity analysis where small dimensional modifications are often involved. Without a convenient, interactive interface to perform the tasks, the practical usefulness of a design is limited. A state of the art interface can provide built-in knowledge and design automation.

Phase I: To develop a graphical user interface for specifying printed antennas and arrays in a multi-layer environment. The interface must include circuit elements found in the feed network and the range of transmission

media employed in the feed network a s well as the radiating element.

Phase II: Expand the user interface and electromagnetic simulator tools to include applications specific Green's function module and to provide capability to link the module with the simulation engine.

Potential Commercial Market: The technology obtained will have application to a wide variety of portable electronic systems. Antenna system efficiency and array processing will play a key role in reducing power requirements, hence, reduction of battery requirements. This effort will have direct application to the entire range of "wireless" systems now under evaluation and to systems operating on the "Information Highway."

TOPIC: A94-031Title:Improving System Sensitivities for Army ELINT and ESM Systems
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate concepts for improving overall system sensitivities of Army ELINT and ESM systems.

DESCRIPTION: The preponderance of recent analytic and experimental signal detection development have focused on detection of the amplitude of a received signal against system noise amplitude background. Emphasis has been on methods to increase the amplitude of the received signal via a variety of approaches to make the detection process coherent relative to the carrier phase in a matched filter context. In every case, the classical radar "ideal correlation detector" cross correlates an exact replica of the transmitted pulse with the target return to accomplish coherent detection. The preoccupation with waveform coherency has limited spread spectrum and/or low probability of intercept or detection system designs to the use of either pseudo-random "noiselike" waveforms or the use of a true noise waveform plus a reference signal. the resulting waveforms have intrinsic features (e.g. spreading chip rate) that can be detected by conventional feature detectors. Systems or major military importance, such as electronic intelligence (ELINT) systems and electronic support measures (ESM), which deal with uncooperative signal detection and processing,m are generally not afforded the opportunity for ideally matched filter signal detection and often only incomplete definition of the target signal is available. The net result of these factors is a system with marginal sensitivity. Alternative analog and/or digital parameters, such as spatial processing, are sought for coherent processing of these signals.

Phase I: Investigate alternative analog/digital concepts for coherent detection and processing of ELINT and ESM signals. Parameters should include examination of angle and phase of arrival.

Phase II: Fabricate a laboratory breadboard coherent processor that can demonstrate quantitative improvement in sensitivity for an existing Army ELINT system, for example, the QuickLook system.

Phase III: Fabricate a flyable prototype processor design that can demonstrate significant improvement in QuickLook, or other ELINT/ESM coherent detection and processing functions.

Potential Commercial Market: Substantial improvement can be provided for air traffic control surveillance and control radar system operation and for other receivers requiring large signal to noise performance for target signal classification and recognition.

TOPIC: A94-032TITLE:Dispersed Command Post Technology: Virtual Conferencing
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Development of the capability to establish and conduct a virtual conference.

DESCRIPTION: For survivability, future command posts will be established and operate in a dispersed configuration. These command posts will consist of small, highly mobile elements. The commander and his staff officers will each operate from one of these elements. Face-to-face communications will be effected through the use of audio and video teleconferencing, data distribution and virtual reality. Audio, real time video, three-dimensional visualization of terrain, and images of maps, overlays, functional equipment, and participants will be combined into the virtual reality space of each commander and staff officer. The virtual reality space of each conference participant will reside in his own local computer. The commander will have complete freedom to move about the battlefield, interfacing with his subordinate commanders and staff via a virtual conference. He will have the same facilities immediately at his disposal whether he is dismounted at a forward observation post, seated in his command vehicle, or being briefed in a face-to-face session at his main command post.

Phase I: The phase I effort will focus on establishment of an architecture for the virtual conference. This architecture must be robust enough to permit rapid expansion of system capabilities as hardware and software technology improves. Initial design of significant system features will be completed and tested.

Phase II: The Phase II effort will construct a demonstration system incorporating the Phase I architecture at the level of capability then available.

Potential Commercial Market: Projects requiring cooperative performance including: Virtual Offices, Robotics Control, Telepresence, and Hazardous Material Handling.

TOPIC: A94-033TITLE:Signal Recovery Via Wavelet De-Noising Techniques
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: To investigate, develop and demonstrate wavelet de-noising techniques as a robust means to recover signal features in a noisy environment.

DESCRIPTION: Current methods of signal recovery from noisy data usually rely on some means of linear smoothing to reduce the noise. These techniques have undesirable effects which include broadening and sometimes entirely masking features. The goal of this research is to derive and demonstrate efficient de-noising algorithms and techniques based on wavelet theory that preclude the undesired properties. Wavelet thresholding and wavelet shrinkage techniques have been shown to detect and preserve features that other techniques cannot, while at the same time achieving better noise suppression.

Phase I: Investigate theoretical approaches, develop and simulate methods and techniques, and document the methods and performance results in a Phase I report.

Phase II: Implement and demonstrate computationally efficient techniques on appropriate commercially available processing hardware to illustrate the operational feasibility and functionality of the algorithms.

Potential Commercial Market: This technology would have wide application in the commercial market. Any application that uses signal processing or image processing techniques on noisy data would benefit from these techniques. Some potential uses are in: the communications industry (e.g., cellular phones, receivers, modems), and the medical imaging industry.

TOPIC: A94-034TITLE:Self Adapting Receiver
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: To develop an innovative receiver technology which will permit a receiver to autonomously adapt itself for optimum sensitivity to a selected signal given that a high signal to noise ratio sample of the selected signal is present for a very brief period.

DESCRIPTION: In many cases (e.g., an Electronic Support Measures (ESM), Electronic Intelligence System (ELINT)) the target signal is at a high signal to noise ratio occasionally (e.g., when the main beam of a target radar illuminates the receiver). In general, there is no a priori knowledge of the target signal, it is first recognized as such when at the high signal to noise ratio. In order to continue to receive the signal, at a very low signal to noise ratio it is necessary for the receiver to reconfigure itself into the equivalent of a matched filter. The waveforms of interest include, but are not limited to, Continuous Wave (CW), FM CW, AM CW fixed frequency pulses (including frequency hoppers, where center frequency is the only change), multi-phase coded direct sequence spread spectrum (pulse and CW), and FM modulated pulses.

Phase I: Develop approach, design prototype receiver to test candidate approaches, simulate/analyze to demonstrate proposed approach for Phase II.

Phase II: Conduct/demonstrate prototype receiver. Explore commercial/military spin offs and applications.

Potential Commercial Market: The techniques developed on this SBIR are applicable to a wide variety of systems: cellular communications over very wide geographic regions with very different protocols entertainment (e.g., car radio/TV that don't fade out), SATCOM on the move, ELINT/ESM/COMINT systems.

TOPIC: A94-035TITLE:High Frequency Single-Site Location (SSL) Improvement
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Improve High Frequency (HF) SSL accuracy by using a compact polarizationally diverse HF antenna array to develop an ionospheric model which can be updated in near-real-time.

DESCRIPTION: A compact, polarizationally diverse, HF antenna array (the "CART" antenna) will serve as the front end to a processor which separates the Ordinary and Extraordinary ("O" and "E") rays present in skywave signals. The horizontally and vertically polarized components of the signal can be processed with a resultant improvement in SSL accuracy. Intelligence and Electronic Warfare Directorate (IEWD) has already designed and built polarization diversity combiners for the CART antenna. During FY93, IEWD built and successfully demonstrated a broadband interference canceler using this antenna. Interference cancellation is achieved by steering the antenna pattern's null at the interferer. The ability to generate multiple nulls is being developed. The work proposed will leverage this technology to provide system solutions to Army HF communications and geo-location problems. A compact HF antenna array (the "CART" antenna) has been developed for IEWD by Flam and Russell, Inc., Horsham, PA. This antenna and/or ruggedized model of this antenna will be used in the course of this work. Phase I: A theoretical analysis of the degree of separability of the O and E rays by the CART antenna will be performed. The ability of the CART antenna to measure arrival angles with sufficient accuracy to permit inverse ray tracing will be evaluated. Accuracy improvements will be assessed and compared with present system accuracies. Candidate separation techniques will be identified and simulated. They will be verified in non-real-time using signal data collected from cooperative and non-cooperative emitters.

Phase II: If Phase I is successful, the follow-on work will concentrate on the design and development of a high speed RF processor. Initial test and evaluation of the processor will be performed at IEWD facilities located at Vint Hill Farms. Additional field tests will be performed at the National Training Center, Fort Irwin, CA; and the Technology Assessment Center at Fort Huachuca, AZ. Finally, the performance of the improved locator will be compared with existing SSL technology during blind tests Phase II is expected to require a full 24 months.

Potential Commercial Market: The proven hardware and software will be available for transfer to Army systems which employ SSL techniques. The ability to measure and model the ionosphere in near-real-time will permit improved operational capability in NV IS scenarios. Transition of the technology into long haul HF communications will also be likely. This technology could find commercial applications in the long distance telecommunications arena. Knowledge of the state of the ionosphere combined with the ability to steer the antenna pattern to the optimum launch angle will provide more reliable communications. Improved SSL technology could be used to aid search-and-rescue operations. This would benefit the Merchant Marine.

TOPIC: A94-036TITLE:Focal Plane Array for Staring Laser Radar
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate new and innovative designs of focal plane arrays for staring laser radar. Concepts developed must include process for range and intensity at every pixel of the two dimensional array.

DESCRIPTION: Military tactical and strategic target recognition from air and ground based weapon platforms are currently based on two-dimensional passive, image information. This information is not robust; it is constantly varying depending upon solar a nd weather conditions. Laser radar is a viable solution to providing robust/non-varying information to target recognition processes with the addition of a powerful third-dimension variable, range. Yet, present laser radar technologies utilizes scanners to sweep a single beam across the scene to be imaged which leads to complex, expensive, limited resolution and slow imaging systems. The new and innovative use of focal plane array (FPA) technology for staring laser radar resolves the aforementioned scanner limitations. Integrated FPA with parallel channel range and intensity processing, readout and digitization of each pixel is planned for the receiver. The transmitter will leverage laser technology advances and will be a high efficiency diode-pumped solid state device. This staring laser radar will truly be a solid state imager. The advantages of this all solid state laser radar are: reduced complexity and lower sensor production costs, resistance to shock and vibration (no moving parts), higher quality imagery (no scan artifacts and intra-frame relative pixel motion), angular resolution and scene coverage decoupled from laser pulse repetition frequency limitations (no lag angle), and the high frame rate capability. This technology is applicable to military robotic navigation and obstacle avoidance.

Phase I: Investigate new and innovative designs for FPA. Define requirements of FPA based on mission definition and laser radar system design. Perform detector, processor, and readout analysis. Modeling and analytical evaluation shall be used to predict the merits of the concepts. A baseline shall be established with detailed designs of the FPA and laser radar prepared for implementation.

Phase II: Implementation of the FPA concepts and construction of a staring laser radar system. Prototype designs of the FPA shall be evaluated in the laser radar testbed for evaluation. The prototype designs shall be optimized for producibility and cost effectiveness. Detailed design drawings and specifications shall be developed.

Potential Commercial Market: This technology would have application to the transportation industry and security industry. The development of new and innovative, cost-effective staring laser radars would provide a means for robust collision avoidance for aircraft, trains, trucks and even automobiles. Laser radar's three dimensional information makes it particular attractive to surveillance and intruder sensing.

TOPIC: A94-037TITLE:Microlens Array Development for Staring Forward Looking Infrared (FLIR) Sensors
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: To develop microlens arrays to be applicable to staring FLIR focal plane arrays. Preliminary work was done by SBRC and Loral. This research is needed to incorporate this device in the designing stage of the FLIR system. This will result in a higher fill-factor and less retroreflection from the focal plane.

DESCRIPTION: Microlens arrays are needed to focus the incoming radiation of the detector elements of staring sensors. This has very important impacts on the sensor protection against laser threats. This will prevent spurious reflection from the areas other than the detector elements. Designs and fabrication techniques must be developed before the future generation systems are being fielded.

Phase I: Evaluate current microlens design and fabrication techniques, down-select feasible approaches and show the feasibility.

Phase II: Develop and fabricate a prototype suitable for a staring sensor configuration.

Potential Commercial Market: Develop US capabilities in optical technology and in particular microlens fabrication techniques which has huge impacts in optical reproduction field such as cameras, Xerox machines, and movie cameras, etc.

TOPIC: A94-038TITLE:Dry Lithography of Closed-System Processing
Point of Contact: CECOM

CATEGORY: Basic Research

OBJECTIVE: Develop and demonstrate a lithography technology that is compatible with high-vacuum semiconductor processing equipment. This technology is intended to be used to apply, pattern, and remove stencil masks suitable for etching features with dimensions on the order of several tens of microns in epitaxial semiconductor layers without removing the wafers from a high-vacuum processing environment.

DESCRIPTION: In its most generic form, the conventional procedure for fabricating advanced opto-electronic devices in semiconductor wafers involves deposition of layers, patterning of layers, and removal of layers. Layer materials can be semiconductors, metals, feroelectrics, or oxides. For deposition, some form of evaporation is used; for removal, some form of plasma etching is used. For both of the processes, a wafer is held in a vacuum system. To delineate areas for etching, a sacrificial stencil mask is temporarily fabricated on the surface of a layer. An organic photo resist is the current material of choice for this mask. Resist is a liquid which is applied as droplets, patterned with ultraviolet radiation, and removed with organic solvents. Because resist technology is a "wet" process, a wafer must be removed from the vacuum system. As the complexity of devices increases and the range of materials is extended to include such delicate materials as mercury cadmium telluride and high-temperature superconductors, the push to abandon conventional wet lithography increases. The rationale for doing so is that the surfaces of these materials are damaged upon exposure to air or wet chemicals, and performance of devices is degraded. An alternative to conventional processing is closed system processing. This refers to a concept whereby all device fabrication steps are carried out without removing a wafer from the protective environment of a high vacuum system. Several embodiments of this concept now exist in government and industrial laboratories. Typically, they are a collection of individual vacuum modules connected by a high vacuum wafer-transfer mechanism. Molecular beam epitaxy deposition modules and plasma etching modules are particularly compatible with such an arrangement. Since layer deposition and etching are already vacuum processes, the only barrier to a full exploitation of the closed-system concept is the lack of a technique for mask fabrication in vacuum. What is needed is a dry lithography technology - processes and equipment for applying, patterning, and removing a contact mask, all of which are compatible with a high-vacuum environment.

Phase I: Demonstrate feasibility of a resist technology that is compatible with high-vacuum processing environments. On a semiconductor wafer held in a vacuum system, deposit a mask, transfer a pattern to the mask, open holes in the mask, and remove the mask.

Phase II: Demonstrate that the technology can be used in a closed-system semiconductor processing environment by integrating the process developed in Phase I with the Night Vision and Electronic Sensors Directorate (NVESD) microfactory located in Fort Belvoir, Virginia. This microfactory consists of five vacuum chambers and an interconnecting wafer-transfer module. Epitaxial layers of silicon, gallium arsenide, and mercury cadmium telluride are deposited and plasma etched in these chambers. In concert with NVESD scientists, utilize the microfactory and the dry lithography process to fabricate an array of mesas on various layers of these materials.

Potential Commercial Market: Diode lasers and high-electron- mobility transistors are now produced in gallium arsenide by molecular beam epitaxy and wet-chemical processing. It is anticipated that infrared imaging devices will soon be produced by mbe of mercury cadmium telluride and identifical wet-chemical processing. When low-dimensional structures emerge from research laboratories and enter a development phase, similar processing will be used. The manufacturing yield for these and other commercial semiconductor products would be significantly increased if a dry lithography process were to be made available.

TOPIC: A94-039TITLE:Use of High Resolution Global Positioning Satellite Data in Automated Ground Truth
Point of Contact: CECOM

CATEGORY: Advanced Development

OBJECTIVE: Development of a stand-alone Global Positioning Satellite (GPS)-based automated ground truth system.

DESCRIPTION: One of the critical tasks in the evaluation of target acquisition skills of both humans and machines is comparison of the "believed" location of a target (as given by the human or target acquisition machine) with the "true" location of a given target. This "true" location of a target is called the ground truth for that target. However, this rather simple comparison is, in reality, very complex. One of the reasons for its complexity is the labor intensive nature of the task. this leads to errors in t he calculation of the performance probabilities. One of the methods for eliminating errors is to extensively use automation in the generation of ground truth files. The use of Global Positioning Satellite (GPS) data has been suggested as one of the promising methods of automation. The goal of ground truth automation is the creation of files with sufficient resolution of x, y, and height so that the location of a target at those coordinates can be projected to the image plane of a sensor for automated scoring . The system must work with both stationary and slowly moving ground targets (less than 20kph). Previous experience with use of commercial GPS equipment has shown that the standard configuration does not have sufficient resolution to support automated ground truthing. There are schemes for improving the resolution of GPS output. Analysis has shown that, in earth coordinates, target location must be resolved to 2 meters (x,y, and z) to be sufficient for automation. This task requires the development and demonstration of a stand-alone system that is capable of meeting the requirements for ground truth automation.

Phase I: Identify GPS equipment and data and information processing procedures adequate for producing output products of sufficient resolution to solve problem.

Phase II: Develop and demonstrate stand-alone prototype ground truth system whose output can be integrated with images.

Potential Commercial Market: In the sense of this SBIR, ground truth refers to the tracking of objects through space and time. Commercial applications that require the tracking of data through time and space using GPS could benefit from this work. For example, tracking of rail cars, truck vans, produce, taxi cabs, ambulances, police cars, etc. could benefit from this work.

TOPIC: A94-040TITLE:Optical Links for Cryogenic Focal-Plane Array Readout
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate concepts for optical links to implement a digital interface to a cryogenic infrared focal-plane array (IR FPA).

DESCRIPTION: This topic presumes the development of an IR FPA with digital outputs; i.e., incorporation of analog-to-digital converters on the FPA. Assuming that these digital data channels exist, it is highly desirable to implement a wireless link through the dewar wall in order to: 1.) Minimize the thermal conductance to the FPA, 2.) Electrically isolate the FPA from the downstream system electronics, and 3.) Reduce the difficulty involved in replacing the dewar. In order to achieve any cooling advantage the power dissipation on the FPA per optical link must be significantly less than the heat conducted in by the wire which the optical link would replace. Also the part of the optical link resident on the FPA must have minimal thermal mass so that cool down time is not unacceptably prolonged. This part of the optical link must also operate at cryogenic temperatures. A typical data rate to be expected is 640 X 480 X 60 Hz X 12 bits/pixel, or ~200 megabits/sec.

Phase I: Investigate concepts for a digital optical link for transmitting digital video from a cryogenic FPA. The approach may be multichannel and should be capable of sustaining a total data rate of 200 Mbit/sec. Modelling and analytical evaluation shall be used to predict the success of the concepts.

Phase II: Fabricate a demonstration prototype, utilizing a dummy FPA data generator operating at 77 Kelvin, proving 100% accurate data transfer at 200 Mbit/sec. The prototype design shall be optimized for producibility and cost. Detailed design drawings and specifications shall be developed.

Potential Commercial Market: In a digital-output IR FPA this technology would have numerous commercial applications, including aid in aircraft landing/takeoff, remote tower forest fire detection, remote surveillance, etc.

TOPIC: A94-041TITLE:Analog-to-Digital Converters on Infrared Focal Plane Arrays
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate an infrared focal plane array (IR FPA) with analog-to-digital conversion incorporated on the FPA. Concepts may include multiple analog-to-digital converters (ADC's) operating in parallel.

DESCRIPTION: Current IR FPA's generate several streams of time-multiplexed analog video output and buffer these streams to drive off-focal-plane ADC's. It has lately become possible to move the ADC'S onto the FPA, which would provide several advantages, including elimination of noise due to signal cross-coupling between analog lines running from the FPA and reduced power consumption on the FPA since low-power digital drivers would replace the analog video buffers. Also, more compact systems can be designed, with all of the analog electronics on the FPA. Concepts developed under this topic must be capable of operation at cryogenic temperatures and must be capable of being scaled down to an array consisting of 25 micron unit cells, although demonstration will only be required with an array consisting of 50 micron unit cells.

Phase I: Design a readout integrated circuit (ROIC) incorporating ADC's. Modelling and simulation shall be used to predict the success of the design, at room temperature and at 77 Kelvin. The baseline architecture shall be a 64 X 64 element array with a unit cell dimension of 50 X 50 microns, and the approach shall also be proved feasible f the unit cell dimension were to be reduced to 25 X 25 microns. It shall be assumed that a compatible array of long-wavelength IR (8 to 12 micron) detectors will be bump-bonded to the ROIC. Total power dissipation shall be less than 20 milliwatts.

Phase II: Fabricate a demonstration model of the ROIC, bunp-bond it to a (government furnished) Long Wave Length Infrared (LWIR) detector array, and test the complete FPA. The prototype design shall be optimized for

producibility and cost. Detailed drawings and specifications shall be developed.

Potential Commercial Market: This technology would have application to commercial infrared and visible FPA's, particularly those applications requiring a digital image.

TOPIC: A94-042TITLE:Compact Mid-Infrared Laser Source
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate innovative compact and efficient laser which will meet the Advanced Research Projects Agency (ARPA)/tri-service requirements for a Mid-infrared laser source.

DESCRIPTION: High repetition rate lasers emitting at several atmospheric transmission bands in the mid-infrared simultaneously are required for DoD applications such as laser radar and infrared countermeasures (IRCM). The main requirements are 2 to 5 watts per band, 10 kHz to 20 kHz (or higher) repetition rates, 25% duty factor, and tunable operation in the main atmospheric transmission bands between 2 and 5 microns. Innovative approaches are needed to achieve rugged, compact, efficient and producible laser sources which will operate in military environments.

Phase I: Demonstrate efficient operation in the laboratory at least one watt per band.

Phase II: Demonstrate a compact device which will meet the requirements as stated in the description.

Potential Commercial Market: Potential commercial applications include eyesafe laser radar for aircraft and vehicles for collision avoidance, terrain mapping, and remote environmental sensing.

TOPIC: A94-043TITLE:Visual Programming for Ada 9X Software Applications
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Determine methods and appropriate automated support that will facilitate visual programming for software applications, in particular mission-critical, using Ada 9X as the implementation language.

DESCRIPTION: Software is an essential (often the essential) component of most military and commercial systems. As these systems become more complex, software complexity increases correspondingly. This radically increases the difficulties encountered in software development and maintenance. Visual design methods offer a means for assisting developers and maintainers in "seeing" the complexity of the software program, allowing them to identify areas that need further attention to avoid major problems being encountered later in the development. Visual programming also enhances the communication required between management and the design team further increasing productivity. To be usable and effective, these methods must follow good software engineering principles, include visual design representation that is integral to the method, and ensure that the implemented code can be directly traced to the design. The Ada language revision, Ada 9X, will result in increased capabilities for the development of Army systems, in particular mission-critical. These capabilities will include, for example, facilities for real-time programming such as data synchronization with protected types, support for programming-in-the-large, and support for object-oriented programming concepts. Methods that currently exist for supporting the design of software using Ada 83 will have to be extended and adapted to incorporate all of the features proposed for Ada 9X. Methods that support Ada 9X, a standard language built on software engineering principles, and visual programming will be of the most benefit to software developers, resulting in more reliable and cost effective developments and lowering software maintenance and support costs, as well. This SBIR will address the issues associated with providing visual design methods, and associated

automated support, for Ada 9X software for embedded and non-embedded applications. This may include but not be limited to: the selection of a method, based on a sound software engineering approach, that uses visual representations that correspond to the entire proposed Ada 9X language revision and approach for addressing issues such as use of domain specific software architectures and application performance considerations.

Phase I: Select a visual design method and define automated support needed for the creation of Ada 9X software for embedded and non-embedded applications. All features in the 9X version of the language must be addressed. Define approach(es) for addressing issues such as use of domain specific software architectures and application performance considerations.Additional consideration will be given for proposals that identify potential users, military and commercial, of the proposed product.

Phase II: Develop a prototype implementation that incorporates and demonstrates the approach and support proposed in Phase I.

Potential Commercial Market: The number of commercial companies using Ada for their large software projects is increasing. Using an effective visual design method that incorporates the advantages and features of Ada 9X and has automated support, will result in the more cost effective, reliable, and supportable software for a wider range of their products, and will also ensure a greater market for Ada in the future.

TOPIC: A94-044TITLE:Management Metrics Decision System
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop a management metrics expert rule-based decision system to assist managers in making programmatic and technical decisions concerning management metrics program implementations on software projects.

DESCRIPTION: There is a critical need to furnish high-level insight, of software life-cycle processes and products, to give managers control over project direction. This comes from smart use of software management metrics as a quantitative technique to complement other methods of monitoring and control. Managers need assistance in making decisions concerning establishing a metrics program (what measures, data items and resources are required to track risks associated with system requirements and programmatic issues); and in implementing a metrics program (menu-driven analysis and interpretation techniques; and what corrective actions are available and reasonable to apply in light of probable risk). The decision system will be used for "what if" sensitivity studies, trade-off analyses of resource requirements, and to help decide alternative courses of corrective action based on metrics reports and correlations. Flexibility is needed to accommodate existing metrics sets, and how each addresses primary manager issues an concerns.

Phase I: Demonstrate proof-of-concept and feasibility. Develop a plan of approach. Address risk and technical alternatives.

Phase II: Develop prototype of the system and provide a demonstration of its capabilities. Develop technology transfer mechanisms such as informal seminars and, hands-on tutoring including management game scenarios.

Potential Commercial Market: This automated technology is of prime interest to acquisition organizations charged with development of large, complex defense software systems. And, therefore, also of prime interest to private sector defense contractors. Consideration will be given those proposals identifying candidate beta sites, pilot projects and users, from both government and industry.

TOPIC: A94-045TITLE:Narrow Band HF Data Networking Algorithm
Point of Contact: CECOM

CATEGORY: Exploratory Development

OBJECTIVE: Establish data routing algorithm for a network of HF transmitting sites taking into consideration propagation anomalies as well as traffic congestion.

DESCRIPTION: The HF channel characteristics have a profound effect on the performance of a communication system. The system performance can be influenced by such terms as receiver sensitivity, noise bandwidth, transmitted power levels, and antenna gain. But the midlatitude channel path is dominated by terms as propagation delays, amplitude distortions which are typically variable and unique on each path. The development of an HF data networking algorithm should consider a propagation dependent hierarchical network in which trade off are highlighted as a function of the number of nodes in the network. Emphasis should be placed on development of an algorithm which maximizes message thruput. The routing algorithm shall conform as closely as possible the existing Military Standards which address issues related to tactical and long-haul communications. The MIL-STD-188-220 document considers digital message transfer devices (DMTDs), and identifies the procedure, protocols, and parameters to be applied in specifications for DMTDs. Channel access methods are frequently documented in the literature. There is no interest in further documentation on the virtues of TDMA, CDMA, and CSMA.

Phase I: Outline candidate algorithms which address issue of narrow band HF data networking protocols. Assess the relative merits of selected candidates. Devise a test plan which would be necessary to fully judge the relative merits of each candidate. Simulation as well as on the air testing should be proposed in order to make the proper selection.

Phase II: Develop and fabricate a laboratory testbed which can be used to test candidate waveforms protocols. Channel conditions should be programmable to simulate channel conditions. Skywave networking tests should be conducted during this period.

Potential Commercial Market: This technology would have application to various DOD and the commercial communication industry. The protocol developed we insure interoperability between all users of HF communication equipment.

TOPIC: A94-046TITLE:Efficient DC-DC Power Converters
Point of Contact: CECOM

CATEGORY: Advanced Development

OBJECTIVE: To develop DC-DC power converters with higher that 90% conversion efficiency for use in portable Military Communications Systems including SCAMP Block II.

DESCRIPTION: High efficiency DC-DC power converters will extend the life of the power source and lower the heat dissipation of the power converters, two concerns of portable electronic devices.

Phase I: Development and Brassboard.

Phase II: Further efficiency improvement and prototype.

Potential Commercial Market: This new technology will extend battery life of battery powered devices, therefore all commercial portable electronic devices (i.e. notebook PCs, cordless/cellular phones, camcorders) are potential markets for this technology.

TOPIC: A94-047TITLE:Advanced Optics for Imaging Infrared Seekers
Point of Contact: MICOM

CATEGORY: Exploratory Development

OBJECTIVE: To investigate and develop innovative objective optics for imaging infrared seekers utilizing staring focal plane arrays (FPA) in general, and uncooled FPAs in particular.

DESCRIPTION: There has been a large investment by the DOD in both uncooled and other FPAs over the past several years. The uncooled FPA technology is very attractive from a seeker design standpoint because it does not require high pressure coolant gas and its attendant design complications. However, to achieve the seeker sensitivity required for operation in degraded weather and battlefield obscurants, the uncooled FPA must be utilized with a very fast imaging optics (low f/no.). When this requirement is coupled with the requirements for high resolution (i.e.. long focal length), the utility of the uncooled FPA is diminished for seeker applications. This is due to the fact that very limited seeker volume is available and high resolution, low f/no. optics are expensive and bulky. To increase the utility of uncooled FPAs in imaging infrared seekers for tactical missile applications, innovative optical designs are needed. Because of look angle requirements and limitations of gimbal torque motors, the optics need to be light in weight and physically short in length. The optical resolution must be very good (equal to or less than 0.25 MR) over a relatively large field of view (equal to or greater than 10 degrees). The potential for producing the optics at low cost (i.e.. amenable to advanced production techniques) must be a consideration in the design. Performance over wide spectral bandwidths is desired by the optics can be tailored for either the MWIR or LWIR if necessary to meet design objectives. A design which maximizes detector cold shield efficiency is desirable and elimination of narcissus effects is mandatory. The optics may include reflective, refractive and binary optic elements to achieve design goals. Ultimately, the design must accommodate the inclusion of a missile dome (probably hemispherical in shape) although a dome is not necessary fort this effort.

Phase I: Provide detailed analysis of at least two different conceptual designs through a preliminary design and performance prediction effort.

Phase II: Develop a detailed design and fabricate hardware for demonstration and testing to verify the conceptual design feasibility.

Potential Commercial Market: In addition to missile seeker applications, this item can be used on any infrared imaging sensor to improve the sensitivity and reduce sensor cost. This includes intrusion devices, law enforcement night viewing devices, forest fire detection devices, temperature measuring sensors, etc.

TOPIC: A94-048TITLE:Digital Data Rate Interpolator and Modulator
Point of Contact: MICOM

CATEGORY: Exploratory Development

OBJECTIVE: Design and build a digital I/Q data (14-bit fixed point) interpolator and quadrature amplitude modulator capable of 8 MHz digital I/Q modulation on a 40 MHz digitally-synthesize carrier, using a 20 - 1 rate interpolation FIR filter. Better than 65 dB spurious suppression is required for the digital sampled output signal.

DESCRIPTION: The MICOM Advanced Simulation Center uses digital Quadrature Amplitude Modulation (QAM) to generate radar target and clutter signatures for Hardware-in-the-Loop missile simulations. Digital QAM has been adopted over other modulation techniques due to its direct utilization of computer-generated complex number data and its maintenance-free I/Q channel gain and phase matching. Future simulation requirements call for digital QAM at higher rates than can be generated using off-the-shelf DSP components. The need exists to investigate the feasibility and cost of developing a fixed-point rate interpolator IC capable of at least 1.28 billion 14x14-bit multiply-accumulate operations per second.

Phase I: Design and fully simulate an IC to meet the requirements stated above. Incorporate design features

to permit integration of multiple ICs in a scalable architecture. Evaluate the design of difficulty and cost to produce the IC.

Phase II: Manufacture, test and demonstrate prototypes.

Potential Commercial Market: Applications include video rate conversion and QAM for the telecommunications and television industries. May also be used in conjunction with high performance digital frequency synthesis.

TOPIC: A94-049TITLE:Missile System Operations Control System Technology
Point of Contact: MICOM

CATEGORY: Exploratory Development

OBJECTIVE: Development and demonstration of a missile system Operations Control System to be used for direct and indirect fire missile systems.

DESCRIPTION: Many control systems and associated technologies currently exist for direct and indirect fire missile systems. New smart missile weapon systems are in development and will replace existing systems. New methods for battlefield damage assessment, intelligence collection, firing doctrine, target acquisition, communications, and identification of friend and foe are either in development, engineering, production, or in the field army. The feasibility of integration of a high fidelity missile weapons command and control system from non-development-item (NDI) hardware and software needs to be assessed. This proposal will determine feasibility of either NDI technology or will develop portions or all the components required for Operational Control of ne w smart missile systems.

Phase I: Review all existing joint service command and control systems and technologies. Formulate and define the conceptual design of a direct and indirect fire missile system operations control and develop the functional specification to the forth level.

Phase II: Using the data developed and collected in Phase I, assess the feasibility and utility of using NDI hardware and software to fulfill the functional specifications. Determine the hardware and software technological shortfalls and changes necessary to meet the functional specifications and develop a full-up laboratory demonstration. Provide all technical specifications and data necessary for simulation and evaluation of the subject concept in a distributed simulation environment. Optimize hardware and software designs based on laboratory testing and provide complete documentation of the operations control system.

Potential Commercial Market: Law enforcement use by the counterdrug, state and local police. Potential use by commercial carriers for status, location and control of vehicles, products and personnel.

TOPIC: A94-050TITLE:Acoustic Tracking of Remote, Up to 4 Kilometers, Moving Sources Using Multiple Microphone Array Beamforming Methods
Point of Contact: TACOM

CATEGORY: Exploratory Development

OBJECTIVE:To develop an array signal processing system for acoustic sensors based on available beamforming techniques that will estimate the direction of arrival of complex ground combat vehicle acoustic signals, provide exterior noise rejection and self- noise reduction.

DESCRIPTION: The acoustic signature measurement capability of Army ground combat vehicle can be significantly improved by using beamforming techniques to continuously measure the received signal during signature gathering

encounters. An eight microphone array system with proper signal conditioning and analysis tools can measure the continuous directivity of incoming threat vehicles. This program will design and develop a real time array based beamforming system that will be targeted for combat vehicle platforms. The beamforming system that is to be developed in Phase I shall have the capability to nulling out all acoustic interference from sources such as generators, stationary vehicles, etc. This program will adapt existing software presently being used as target classifiers and apply them to the beamforming system as directivity measurement tools.

Phase I: The program will provide a developed plan of the necessary hardware required to perform the task. The program is to provide specifications and purchase off the shelf required components essential for operation of the signal measurement system, such as anti-aliasing filters, analog to digital convertors, digital signal processors, etc. The program will also provide specifications, and purchase, a rugged portable host computer with 20 MB memory and 200 MB disk. This phase will develop the high resolution beam forming based acoustic directivity system and be able to determine the directivity of ground vehicles for distances up to 2.5 km from the array. It is expected that the bearing estimator is to consist of 12-24 beams with a bearing estimation accuracy of 2 - 3 degrees. This phase will provide a real time operational software based system that has feature extraction and classification capabilities, including FFT spectral analysis display, test situation display and developed database acquisition capability. The developed system shall operate in C using the Unix Operating System. The contractor is to deliver a ruggedized eight microphone array whose geometry can be resolved from linear, circular and elliptical shapes. This phase will also deliver the complete operational system based on a ruggedized portable computer. All source code required for operation of the signal measurement array system will be the property of the U.S. government and will be controlled by TACOM. Training for TACOM personnel in the operational use of the measurement system will be provided in this phase.

Phase II: The beamforming measurement system is to be developed further by improving the analysis tools, algorithms and internal data bases. The developed system is to be field tested during a demonstration of selected targets.

Potential Commercial Market: The beamforming system will be able to track airport ground traffic at commercial airports. The present system in use at commercial airports is out of date and the developed system could serve as the basis of updating the system.

TOPIC: A94-051TITLE:Applications of Radar Imaging to High Altitude Measurements
Point of Contact: TECOM

CATEGORY: Exploratory Development

OBJECTIVE: Adapt radar imaging technology to test center measurement requirements such as attitude of missiles and aircraft, miss distance between interceptor and target, detection of deployed objects, and determination of extent of damage to targets, all at high altitudes or long ranges.

DESCRIPTION: The U.S. Army White Sands Missile Range has developed measurement and processing techniques for extracting more and better information from coherent radar signals. Improved measurements include trajectory parameters, motion about the center of mass (e.g. spin and coning) and characteristics of events (e.g. time of occurrence and duration). Recent advances in radar imaging suggest it is now possible to adapt imaging technology to obtain even more information in the test center environment. Of particular interest are measurements of attitude of missiles and aircraft, measurements of miss distances of high-altitude missile and target engagements, detection of deployed objects, and determination of extent of damage (i.e, damage/kill assessment). In general, the requirement is to make measurements at high altitudes or long ranges where optical data are not available and where current instrumentation radars are incapable of making the measurements to the desired accuracy (e.g. miss distance to +/- 1 ft) or making the measurements at all (e.g. damage assessment).

Phase I: Research is required to determine the extent to which radar imaging technology is applicable to those measurements, to characterize the problems to be solved (e.g. resolution of individual scattering centers, elimination of

acceleration smearing, stabilization of shifting phase centers, and identification and correction of multiple-bounce returns), and to specify the upgrades needed for the WSMR instrumentation radars and data processing facilities.

Phase II: Develop a prototype processor to make the radar images and extract the desired measurements. Some human intervention may be needed in the measurement process, but the prototype system should be as autonomous as possible, particularly in the arduous task of deriving the radar image from the coherent video data. Although the system will be designed for making measurements at long ranges, it should also work at the shorter ranges employed in many of the tests conducted at WSMR.

Potential Commercial Market: Development of this technology could expand radar applications for numerous commercial uses.

TOPIC: A94-052TITLE:Rapid Mapping
Point of Contact: TEC

CATEGORY: Exploratory Development

OBJECTIVE: Achieve classification and feature extraction for data having digital terrain elevations (DTE) with post spacings of ten meters of less and corresponding fine resolution SAR imagery generated from interferometric synthetic aperture radar data. Pixels are to be automatically allocated to one of a number of categories such as trees, grass, water, or built-up areas, boundaries are to be defined between these categories. In addition, automated extraction of man-made features such as roads, bridges, airports, and perhaps buildings is desired as are delineation of naturally occurring features such as elevation contours and drainage patterns.

DESCRIPTION: Recent advances in synthetic aperture radar (SAR) technology, in particular interferometric SAR (IF SAR), the advent of the Global Positioning System and high throughput computing offer the potential for generating digital DTE and imagery wit h fine resolution and high elevation accuracy. This offers the possibility of the rapid generation of map products for the support of military operations as well as civilian applications.

Phase I: Demonstrate the potential for classification and feature extraction using IF SAR data using automated computer technology consisting of either conventional computer vision routines or neural nets or combinations of both. Assess the accuracy of t he performance of these algorithms.

Phase II: Extend algorithm development to address problems known to be likely in the data, such as shadows (no data) and variations due to terrain categories ranging from heavily forested to desert. Assess changes in algorithms and their expected performance for a variety of environments.

Potential Commercial Market: Automated mapping, and particularly automated generation of DTE, is highly relevant to many civilian applications such as replacement of optical technology for conventional map generation and for special purpose applications such as geological exploration, surveys for construction such as roadways or rail lines, and environmental assessments.

TOPIC: A94-053TITLE:Antenna Monopulse Measurement Modeling and Calibration for Improved Tracking
Point of Contact: SDC

CATEGORY: Exploratory Development

OBJECTIVE: Develop a method and algorithms for calibrating antenna monopulse measurements to permit accurate off-axis tracking of depolarizing targets

DESCRIPTION: With the increased desire for Multiple Target Tracking, there is a need to accurately calibrate

monopulse antenna traverse-elevation surfaces to permit accurate tracking of targets off-boresight targets unless corrected. The ALTAIR Radar at the Kwajalein Missile Range (KMR) does not presently correct for these errors. Since the typical 15 minute permission checkout is not adequate for full calibration, it is desired to have an extensive parameterized model that can be updated with the limited p remission checkout data.

Phase I: Investigate the feasibility of quickly updating the model with a small number of adjustable parameters to achieve the angle measurement accuracy requirement. Define, analyze, and evaluate potential monopulse models and associated calibration procedures suitable for permission measurement and computation. Include accuracy estimates as a function of polarization ratio and angle-of-boresight, and select one approach for implementation based on expected accuracy. Provide cost/schedule estimates.

Phase II: For the selected approach, develop a detailed calibration procedure and the software algorithms to process the calibration measurements. Develop software for real-time measurement correction based on the calibration model, and assist in integrating and performance testing the software.

Potential Commercial Market: This study is innovative in its application to allow multiple target tracking within the beam. Phase II proposals should also include an assessment of the commercial applications and markets for use of the models and procedures for calibrating and correcting monopulse angle measurements.

TOPIC: A94-054TITLE:Data Compression for Real-Time Data Recording
Point of Contact: SDC

CATEGORY: Exploratory Development

OBJECTIVE: Design and build a data compression system for direct digital output to allow recording on standard Small Computer System Interface (SCSI) disks.

DESCRIPTION: There is a current need for a direct digital recording system for digital output form the ALTAIR Radar at Kwajalein Missile Range (KMR). At present, eight channels at two frequencies produce 320 MBytes per second of digital output data. Additional non-commercial markets include NASA ionospheric data collection, other Spacetrack radar sites, and scientific data collection.

Phase I: Investigate the performance of data compression algorithms against test radar data from Near Earth targets. Determine the best compression method and data recording media requirements. Project requirements towards available common disk drives.

Phase II: Construct the data compression system. Integrate with commercial, off-the-shelf (COTS) disk drives, and test in the ALTAIR system. Verify recording performance against the present recording system.

Potential Commercial Market: Applications include hi-volume weather, geologic, astronomic, etc., data recording. Phase II proposals should also include an assessment of the commercial applications and markets for use of the data compression system with the FAA air traffic control system and ship traffic radar control systems.

TOPIC: A94-055TITLE:Acoustical Detection of Arcing in High Power Wave Guides
Point of Contact: SDC

CATEGORY: Basic Research

OBJECTIVE: Develop a method to determine the location of an arc in high power waveguides to allow repair without dismantling a large portion of the waveguide.

DESCRIPTION: When high-power waveguides are installed in corrosive environments, the joints in the waveguide

often deteriorate and gaps develop that lead to arcing and then to dangerously high Voltage Standing Wave Ratios (VSWRs) in the waveguide. Since the arc produces an acoustical shock wave, like mini-lighting, microphones can detect the arc and time-to-detection can be used to determine the arc position. A technique using microphones at intervals based upon attenuation along the waveguide, and a time-of-arc based on the start of a pulse or VSWR, could be used.

Phase I: Design, analyze, and build a prototype acoustical detector.

Phase II: Construct and demonstrate the acoustical detector.

Potential Commercial Market: High Power microwave system manufactures and high voltage equipment users are potential users. With some modifications, other acoustical fault detection devices can be developed. Phase II proposals should also include an assessment of the commercial applications and markets for use of the detector.

TOPIC: A94-056TITLE:Data Fusion for Enhanced Deep Space Surveillance
Point of Contact: SDC

CATEGORY: Exploratory Development

OBJECTIVE: Fuse optical and radar data by creating a hybrid state vector consisting of optical angles and radar range/range-rate, for tracks of deep space objects.

DESCRIPTION: Catalog maintenance for deep space satellites could be significantly improved if the radar angles are replaced by optical measurements from an optical sensor. The Kwajalein Missile Range (KMR) ALTAIR radar is located near various optical sensors and is one system that could provide increased accuracy deep space surveillance data by fusing optical and radar data.

Phase I: Determine the benefits to fusing the optical and range/range-rate radar data and specify the necessary upgrades to the optical sensor to allow joint space surveillance operations.

Phase II: Procure commercial, off-the-shelf (COTS) equipment for the optical upgrade and integrate the optical and radar systems to create the new hybrid radar/optical sensor.

Potential Commercial Market: A hybrid radar/optical sensor using COTS equipment is desirable at many RADAR locations where increased accuracy is necessary. Phase II proposals should also include an assessment of the commercial applications and markets.

A-4HIGH PERFORMANCE COMPUTING, COMMUNICATIONS, NETWORKING AND SIMULATION (I.E. MODELING DISPLAYS, AI, VIRTUAL REALITY)

TOPIC: A94-057TITLE:Software Infrastructure Technology For Smart Weapon Applications
Point of Contact: ARDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop design, analysis and prototyping tools and technology to support specification, implementation and evaluation of standard software reference architectures and application components for distributed smart weapon applications.

DESCRIPTION: Embedded software will be a key cost driver in next generation smart and brilliant weapon systems due to increased computational and software complexity, stringent hard real time computational constraints, and the high cost associated with software testing, verification, validation, and software maintenance and support. A key enabling technology for managing and controlling software cost and complexity is the development of standardized

reference architectures and supporting infrastructure technology, tools a nd design methodology. Progress to date includes the development of an architecture schema and architecture description language which provides a formal mechanism for describing architecture components and interconnections, together with preliminary repository tool s for storing, manipulating and visualizing schema data. Further extensions of this technology is required, however, to provide complete end-to- end software development support for distributed intelligent weapon launcher applications. Specific requirements exist for:

(1) domain modeling and analysis tools and methodology which are tailored for extracting reference architecture requirements;

(2) architecture description languages that provide sufficient expressive power to represent component functionality, component interface connections, control and data communication paradigms, etc. and support detailed analysis of architecture behavior/performance;

(3) a repository tool with graphical user interface that supports storage, manipulation, browsing and retrieval of application architecture descriptions and components and the composing of new application systems from existing or re- engineered components;

(4) development of reference architecture specifications for conventional smart weapon launcher systems that facilitates reuse of components within the application domain (e.g. smart mines, smart mortars, intelligent artillery crew associates, etc.);

(5) development of generic architecture/application components that conform to reference architecture specifications to include real time data base management, real time, intelligent multi-processor/ multi-tasking os, MMI, digital mapping, real time planning, resource management/allocation, hybrid systems control, etc.;

(6) application generators; and

(7) metrics for determining conformance of application architectures to reference architecture specifications.

Phase I: Assess maturity and capability of existing tool environments to support an end-to-end architecture based software development process for distributed intelligent weapon launcher applications. Develop preliminary requirements for an integrated tool environment that fully supports an architecture driven software development process.

Phase II: Develop tools and supporting design methodology for executing, as a minimum, critical process threads associated with (a) reference architecture extraction from domain models, (b) representation, analysis and archiving of application architecture descriptions, (c) requirements tracking, (d) application generation based on composing reusable/re-engineered components, from component repositories, with possibly new components produced via component generators. Demonstrate and validate technology by populating a baseline component repository and composing a laboratory application prototype.

Potential Commercial Market: This topic will provide enabling technology that is applicable to the development of all large scale, distributed, real time software systems such as those associated with factory automation, command and control, health services, banking, environmental monitoring, communication networks, etc.

OSCR: This technology will provide significant cost reductions in operation, maintenance and support costs for embedded software systems associated with next generation automated crew stations, smart mines, smart mortars, brilliant munitions, by supporting software component standardization, reuse and customization and enhancing overall system reliability and fault tolerance.

TOPIC: A94-058TITLE:Fire Control Battle Management and Decision Support System Technology
Point of Contact: ARDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate advanced software and expert system decision aids technology for direct, indirect fire and smart mine field control. Develop embedded training for using the expert system decision aids for direct/indirect fire and smart mine field control applications.

DESCRIPTION: The feasibility of developing high performance expert system decision aids for direct and indirect fire systems and smart mine applications has been demonstrated recently based on laboratory prototype tests. Further technology development i s required, however, to address specific algorithmic issues associated with real time planning/replanning, sensor/information fusion, terrain analysis, as well as issues of knowledge engineering, man/machine interface, rapid prototyping and simulation environments for evaluating decision aids. Expert system decision aids which address one or more of the following requirements are of specific interest: (a) Identification Friend or Foe (IFF); (b) Fire Control (acquisition/tracking); (c) tactical planning/order preparation; (d) tactical situation assessment; (e) status/reports; (f) self defense of weapon platform; (g) sustainment; (h) command and control (C2); (i) fire direction; (j) communication; (k) reconnaissance, selection and occupation of position; and (l) embedded training.

Phase I: Develop methodology for design and implementation of distributed expert system decision aids for direct/indirect fire and/or smart mine field control applications. Formulate and define conceptual designs for specific expert system modules including hardware implementation and software prototyping environment. Develop detailed functional specifications.

Phase II: Develop a full-up laboratory technology demonstration prototype decision support system with appropriate displays, simulation driven, development environment and run-time environment. Develop component-based software architecture and tool environment which will support reuse and re-engineering of software components thereby reducing overall software development and maintenance cost of embedded decision support systems. Optimize hardware/software, algorithm and interface design based on laboratory test results and provide complete documentation of hardware/software, analysis and test results.

Potential Commercial Market: Developed technology has potential for commercial wargame products. In addition, required algorithm development in real time planning/replanning, sensor fusion, and terrain analysis can be used in commercial development of decision aids. Embedded training algorithms can be used on a wide variety of commercial software package offering.

OSCR: Developed component based software architecture and tool environment will support reuse and re-engineering of software components, thereby reducing overall software development and maintenance cost of embedded decision support system. Embedded training will reduce training cost on using expert system decision aids for control applications.

TOPIC: A94-059TITLE:Neural Network Limit Avoidance System for Rotorcraft
Point of Contact: AVRDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop a system that can accurately detect the onset of aircraft limit exceedances and take action to avoid them.

DESCRIPTION: Helicopters typically contain complicated limit envelopes which are difficult to predict and poorly annunciated to the pilot. The Army is currently conducting research in the area of envelope limitations and has identified a number of critical limits which generally occur in all helicopters. One needs to be able to sense the onset and then
automatically avoid these limits, to protect the pilot and aircraft from loss of control, to avoid catastrophic failure, to reduce the number of minor exceedances that degrade airframe fatigue life, and to permit the pilot to safely fly the aircraft close to

the edge of the envelope. A primary strength of neural networks is their ability to perform rapid pattern recognition. Given the proper training data, a neural network could be developed that rapidly identifies the onset of limit exceedances based on the pattern presented by aircraft control positions and rates and aircraft body states. Once the limit exceedance information is made available by the neural network, a feedback algorithm could be developed which takes the necessary corrective action to avoid the exceedance.

Phase I: Review theory on helicopter limit exceedances and available databases. Develop a proposal to show how this information could be used to train a neural network for exceedance detection.

Phase II: Develop a neural network that will perform limit exceedance prediction and train it using available test data. Install this network in a high-fidelity Army research simulator and demonstrate its ability to perform limit detection in a real-time environment.

Phase III: Review fuzzy logic theory to determine its potential for forming the basis of a control feedback limit protection scheme. Develop a proposal to show how a fuzzy logic protection algorithm could be implemented. Develop a fuzzy logic limit protection algorithm and demonstrate its capabilities. Install the algorithm in a high-fidelity Army research simulator and demonstrate its ability to protect a helicopter from limit exceedances in a real-time environment.

Potential Commercial Market: With the rapid increase in on-board computational power and replacement of current-day control rigging with automatic fly-by-wire control systems, the achievement of automatic envelope protection becomes practical. The increased safety, extended operational envelope and reduced maintenance requirements that are possible with such a system means that the first company (or country) to bring such a system to market will enjoy a distinct advantage over the rest of the helicopter manufacturing world.

TOPIC: A94-060TITLE:Visual Programming Language Development
Point of Contact: MICOM

CATEGORY: Exploratory Development

OBJECTIVE: The objective of this activity is to extend the concept of object oriented programming to a visual programming paradigm where each software object is an icon with standardized inputs and outputs. Although this has been done in the commercial world in a few narrow applications areas, the application of this concept to software in general has not occurred. The objectives of this task are to begin to formulate standards within DoD which will encourage development of the visual programming paradigm for software in general.

DESCRIPTION: Object oriented programming and software reuse are two DoD initiatives which promise to hold down the rising cost of software development and maintenance. However, neither of these two initiatives address the critical problem of sheer numbers of lines of code nor the problem of standard software interfaces. For example, even a moderately complex system such as the MLRS Improved Fire Control System is expected to contain over 150,000 line of code, and no standard software interfaces have been described for its software modules. These problems are systemic. They exist because the basic element for software definition is the "line of code". Such problems can be addressed in a manner similar to the methods used by engineers designing with integrated circuit s; i.e. circuit details at the transistor level are abstracted away into a functional blocks. Each functional block is represented on the schematic by a rectangle with standardized input and output pins and a defined function. These blocks are then wired together to form the data paths between blocks. Functional blocks can be combined using hierarchical design techniques to form higher level functional entities such as circuit cards or "black boxes". Such a methodology, if applied to software, would greatly simplify the task of designing, implementing, and maintaining software by abstracting away actual code lines into functional blocks. These blocks would have defined (standardized) inputs and outputs and could easily be maintained in a library for reuse. As a side benefit, software testing tools would be easier to develop because of the standard interfaces. By using such techniques, software productivity could be increased by at least an order of magnitude. Current software products are available which implement these concepts for narrow application areas (such

as signal processing). The purpose of this SBIR topic is to extend these concepts to broader applications, to begin development of a standard tool base, and to begin developing DoD standards for the visual programming concept.

Phase I: This phase would begin the primary studies required for the development of a visual language and its associated programming environment. In this phase, the contractor would make an extensive study of existing visual languages, determining their strengths and weaknesses as to application to a general programming environment. The contractor would also investigate ongoing research into visual programming languages and environments and visual language grammars. Based on these investigations, the contractor would make recommendations on such topics as execution paradigms (an example of which is data flow graphs and Petri nets, where a task is instantiated but cannot execute until all of its inputs are available), task-to-task interfaces, visual programming paradigms (for example, would directed graphs or some other method be used to describe a program?), and first-level programming primitives. As part of this phase, the contractor would also give proposals for a complete visual programming system.

Phase II: The second phase of the work consists of a number of subphases, each of which builds on the preceding efforts and are successively more complex. What is ultimately desired as a programming environment in which general-purpose, real-time programs can be developed and maintained as well as a standard way in which software modules can be added to this environment. These subphases would be:

1. Development and documentation of a standard task-to-task interface whereby a software developer can construct executable tasks to run under the visual programming environment.
2. Development of a visual programming environment, in which the user can develop, debug, and execute programs by graphically linking in individually compiled tasks. As part of this environment, there would be some set of "primitive" general-purpose tasks from which the user could reasonably be expected to construct more complex tasks. Once an application has constructed and debugged, the environment would allow the user to produce a stand-alone executable, not requiring the development environment for its execution.
3. Development of a more extensive library of primitives and "compound primitives," that is, tasks created from other primitives. This would allow the development of hierarchical programs as well as reuse library based on specific programming tasks.
4. Because it is desired that this environment be utilized for the development of real-time programs, the requirement for handling of interrupts must be addressed. The contractor will have to address such problems as what is the appropriate size for an "atomic," that is, non-interruptable, operation. The contractor may also have to develop primitives for the synchronization of independent streams of execution. The contractor will have to develop graphical methods for enabling and disabling interrupts, or provide some abstraction which accounts for this.

5. Once the subject of atomic operations is addressed, the contractor will then have to investigate the timing of primitives. This will allow the user to make reasonably accurate assessments of total program execution time. It will also allow the simulation of real-time software systems in non-real-time environments. As these investigations are performed, the contractor can construct tables of execution tie versus memory versus platform for each of the primitives. These tables could then be included in the programming environment, allowing the programmer to select the size and speed of primitive to match the application. This would also allow the development of standardized, reasonable benchmarks by which different hardware/software systems could be compared.

Potential Commercial Market: The potential commercial market is very large. Commercial interests face the same problems as DoD when it comes to software: specifically, high development costs and even higher maintenance costs. The end product of this effort will provide commercial user and the DoD user with a means of controlling, and even significantly reducing, these costs. Also, by its nature, this visual environment should significantly ease the effort in transporting a program from one type of execution platform to another.

TOPIC: A94-061TITLE:Sensor Fusion Implementation with Neural Networks and/or Fuzzy Logic
Point of Contact: MICOM

CATEGORY: Basic Research

OBJECTIVE: Since: 1. Sensor Fusion is multiple, parallel, temporal, and spatial by nature; and 2. many of the elements within Sensor Fusion (e.g., association, classification, correlation, assessment, etc.) are tasks readily performed by neural network (s) and/or fuzzy logic; Sensor Fusion is a field that should be examined for potential improvement(s) by the utilization of Neural Network/Fuzzy Logic (NN/FL) implementation.

DESCRIPTION: Sensor Fusion, a fundamental part of the sensor/processor system can be defined as the merging of data from multiple sensor sources separated by time, location, spectral band, field of perspective, etc. Critical issues include the integration of multiple sensors performing multiple functions of acquisition, tracking, and weapons fire control. There is a need for a variety of sensors, offering a qualitative evaluation of sensor capabilities versus mission requirements. In many scenarios, no sensor may detect every target present but with sensor data fusion, all sensors can jointly contribute to all the targets detection, recognition, and identification. Sensor defects, distortions, and misalignments may be detected and corrected for using fuzzy logic. Other advantages of using NN/FL in Sensor Fusion are: robust operational performance, increased confidence, the ability to handle imprecise data and noise, reduced ambiguity, enhanced spatial resolution, improved system reliability, and increased dimensionality. A "cookbook" of sensor types (e.g., EO/IR, TV, RADAR, Identification-Friend or Foe (IFF), etc.) shall be assembled with their performance characteristics, including any NN/FL techniques required for each sensor's integration and implementation within the Sensor Fusion System. An interactive, user-friendly, query type system shall be provided for adding "additional sensors" and their performance characteristics [including the necessary NN/FL implementation and integration technique(s)] to this data base.

Phase I: Research, develop, and design a sensor types "cookbook" data base containing each sensor's performance characteristics (including sensor defects, distortions, and misalignments). Examine, evaluate, and include in this design, each sensor and its potential for NN/FL implementation and integration within the Sensor Fusion System (SFS), listing its NN/FL characteristics (as identified in the Description:, above). Include all of this data in the Phase I Report.

Phase II: Implement the design of Phase I:, (on a VAX/VMS), such that two SFSs (one conventional and one using NN/FL implementation) can be "built" using a variety of sensor(s) selected from the sensor types "cookbook" data base and/or a variety of sensor from the "additional sensors" data base. Sensor performance data, error analysis data, and NN/FL SFs performance data vs. conventional SFS performance data (for the resulting SFSs) shall be either displayed or printed.

Potential Commercial Market: Multi-Sensor Avionic Systems, Multiple RADAR(s) System, Multi-Sensor Control Systems, Multi-Sensor Identification & Recognition Systems, Multi-Sensor Surveillance and Reconnaissance Systems, Multi-Sensor Robotic Systems, Multi-Sensor Pollution and Environmental Monitoring Systems, and Multi-Sensor Diagnostic Systems.

TOPIC: A94-062TITLE:Locomotion Simulator for Dismounted Troop
Point of Contact: STRICOM

CATEGORY: Exploratory Development

OBJECTIVE: To develop a system that will accurately simulate locomotion through a virtual reality environment.

DESCRIPTION: Ideally, the locomotion simulator will allow a trainee, immersed in a virtual reality environment, to move through the virtual world and across virtual terrain permitting the trainee to walk, run, crawl, and climb as might be required in a combat situation. This simulated locomotion of the trainee should take place without actual translational motion within the fixed reference frame. Yet the simulator would allow the trainee to expend the same energy in the simulator that would result form movement through the real world. The simulator will provide the

appropriate "equal and opposite reaction" forces to the trainee to support his perception of locomotion in the immersive virtual environment. Standard treadmills and/or stair-steppers, as used in gymnasiums and health care facilities constrain motion to the extent that the immersive experience would be compromised.

Phase I: Formulate feasible system concept.

Phase II: Develop and demonstrate feasible prototype system.

Potential Commercial Market: This system has commercial applications in all forms of training involving locomotion (i.e. firefighting, police, football, etc). This technology would augment video games and theme park rides and provide realistic motion platforms for conducting physical rehabilitation.

TOPIC: A94-063TITLE:Virtual Test Range (VTR)
Point of Contact: STRICOM

CATEGORY: Basic Research

OBJECTIVE: Develop a VTR environment, to conduct virtual reality based testing of real and virtual equipment.

DESCRIPTION: It is very expensive and sometimes hazardous to test and qualify military equipment, components and systems. Virtual reality offers some intriguing possibilities to short cut the repetitive development and test process. The VTR will provide and environment and tools to interact with real or virtual prototype systems within the context of system development, and developmental and operational testing. The VTR would allow a developer to test real and virtual breadboards under selected test conditions. System testers will utilize the VTR to definitive test procedures and plans prior to the start of testing and for verification/validation of data both during testing and after testing completed.

Phase I: Develop concept and demonstrate feasibility.

Phase II: Develop and demonstrate prototype system.

Potential Commercial Market: The VTR concept would be applicable to all equipment developer who build and test new design concepts.

TOPIC: A94-064TITLE:Analytical Tools, Effectiveness Models and Interactive Simulations for Ground Vehicle Design Optimization and Virtual Prototyping
Point of Contact: TACOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate innovative and efficient computer models to supplement TARDEC Virtual Prototyping (VP) process.

DESCRIPTION: The VP is a process by which advanced computer simulation enables early evaluation of new vehicle concepts without actually building a physical vehicle. Process lends itself to continuous military user participation which will result in a high degree of user/developer agreement prior to actual building of the hardware system. The steps in the process are as follow:

Step 1: Concepts - Inputs to the concepting process are based on requirements from the user community via the Battle Labs and directorates for Concept Development (DCDs), advanced technologies coming out of the ARL and industry state-of-the-art components. The process starts by developing solid models of alternative concepts such as external versus turreted weapons, tracks versus wheels, etc., to meet the requirements, from which 2D or 3D drawings (solid model) can be produced in a Computer Aided Design (CAD) station.

Step 2: Performance Modeling - Analytical models can be applied to the solid model to evaluate mobility,

vehicle dynamics, track & suspension, survivability, vulnerability, stealth, and lethality. Analytical results are reflected in changes to the solid model to optimize the design through an iterative process. Conflicting requirements require trade-offs which can be done in conjunction with the user.

Step 3: Wargame Modeling - Resulting concept vehicles are next evaluated using wargame models. Initial concept effectiveness screening is done using GROUNDWARS. This is followed by detailed concept effectiveness screening using CASTFOREM.

Step 4: Virtual Mockup/Detailed Design - The selected concept proceeds to a detailed design phase in which the solid model is refined to incorporate actual components, concurrent engineering and logistics support factors in the design. A 3D VP is developed in which the user can actually explore the inside of the vehicle.

Step 5: virtual Factory - concurrent engineering relative to the actual manufacturing processes is provided in parallel with the detailed design phase. The machine tool paths, production line set-up and timing of materials, machining processes and assembly lines for production of parts and the assembly of the whole vehicle system can be laid out and tested prior to the actual implementation on the factory floor. This results in significant time savings and reduction of scrap material.

Step 6: Crew Station Development - The virtual mockup results in a crew station envelope which is used to establish the crew station design using the soldier-in-the-loop crew station simulator under static and dynamic conditions. The crew station simulator is connected to the Distributed Simulation Internet (DSI) to enable a seamless battlefield simulation using remotely located manned simulators to enable the battle labs to evaluate effect of the concept design on tactics and force effectiveness. Phase I: Develop/adapt computer models that support or perform one or more of the functions described in the VP steps 2 & 3 described above for combat vehicles.

Phase II: Develop an automated transfer of information within and/or between the steps described above.

Potential Commercial Market: Many of the models will have application in design development within the commercial sector.

TOPIC: A94-065TITLE:Real-time Vehicle Attitude Estimation System
Point of Contact: TECOM

CATEGORY: Engineering Development

OBJECTIVE: To develop that will produce real-time vehicle attitude estimates by matching object outlines with video image outlines.

DESCRIPTION: White Sands Missile Range tracks missiles, aircraft and submunitions for the purpose of performance evaluation. Optical Tracking Systems that use video as a recording medium are used for this purpose. Objects tracked may have velocities as high as 5000 ft/sec, and video data is generated using 60 non-interlaced fields per second. The attitude (pitch, yaw and roll) of the object being tracked can be estimated be matching the outline of the video image with a catalog of prestored outlines. At least two views of the object from different tracking locations are required to perform this estimation. The quality of the estimation derived is dependent on the video image quality, the number of observing instruments and the accuracy of the catalog of observed images. Real-time implementation of this method of vehicle attitude estimation is required. Systems that accomplish this estimation task using commercial off the shelf hardware and software are preferred. A 60 per second update rate is required. Maximum acceptable system latency is less than 100 milliseconds. Vehicle attitude estimates produced by this system will be used to produce three dimensional graphical presentation of test item performance. High end graphics work stations will be used for these presentations.

Phase I: Develop the system concept for a Vehicle Real-time Attitude Estimation System. Identify candidate commercial hardware and software that can be used to accomplish this function. Demonstrate that the approach chosen will produce real-time vehicle attitude estimates.

Phase II: Design, fabricate, test and demonstrate a Real-time Vehicle Attitude Estimation System. The system

must be produced and demonstrated using real test range data. Accuracy and reliability as a function of video image quality must be verified experimentally as a part of the system demonstration. Producability for Phase III applications is also required as a part of the system demonstration.

Potential Commercial Market: Real-time processing capabilities developed by this effort would be of value to various applications of modeling and simulation, especially with regard to virtual reality simulations.

TOPIC: A94-066TITLE:Image Processing Using Temporal Cellular Neural Networks
Point of Contact: TECOM

CATEGORY: Exploratory Development

OBJECTIVE: Produce a commercial charge coupled device (CCD) camera based on temporal cellular neural networks.

DESCRIPTION: The U.S. Army White Sands Missile Range has been following advanced in the field of neural networks for application in range instrumentation. Previously, these advanced had been confined to artificial neural networks, i.e.simulations of neural networks on conventional computers. Recently, advances have been made which may make it possible to field actual neural network technology for range instrumentation. Demonstration of this technology would require interfacing existing CCD sensors directly with temporal cellular neural networks and creating a CCD/neural network camera where signals can be processed by the neural network in a parallel and continuous manner.

Phase I: Research will be required to study and develop the design of such a camera. Because of the parallel nature of neural networks, an advanced design of how such a camera is interfaced to conventional processors and/or alternative neural network processors for further processing of the sensor data will have to be incorporated.

Phase II: Phase I design and development will lead to the implementation of a prototype version of the CCD/neural network camera. Testing of the camera will require novel techniques and use of available instrumentation.

Potential Commercial Market: True CCD/neural network cameras offer potential breakthroughs in commercial video technology in several areas: first, the standard NTSC signal would no longer be a time constraint for syncing to the video picture; second, the neural network eliminates the need for digitizing a video picture (a significant time savings); finally, neural networks would allow processing to be accomplished continuously so that pattern recognition algorithms could be processed in a fraction of the time it would ta ke conventional processors.

A-5ADVANCED PROPULSION TECHNOLOGIES
(I.E. MOBILITY AND LETHALITY)

TOPIC: A94-067TITLE:Bottoming Cycle for Intercooled Gas Turbine Engines
Point of Contact: VPD

CATEGORY: Exploratory Development

OBJECTIVE: Develop an Effective Bottoming Cycle for Intercooled Gas Turbine Engines

DESCRIPTION: Intercooled gas turbine engines are finding increased application due to their excellent power density attributes. Intercooling, however, requires the rejection of heat which is a net loss to overall system efficiency. An effective bottoming cycle can significantly increase the specific power and fuel efficiency of any gas turbine. While

bottoming cycles have been explored for extracting heat only from the gas turbine engine exhaust, they have generally been heavy, bulky, and complex. Little effort has been directed at using the rejected heat from the intercooler itself, or in combination with the exhaust heat. Innovative methods/concepts (using the Rankine cycle) are sought to produce an effective, compact bottoming cycle for intercooled gas turbines. Focus shall be on the effective integration of the Brayton gas turbine cycle with the Rankine bottoming cycle. Compactness and simplicity of the resulting overall system are of primary importance. Output from the bottoming cycle may be used to increase the shaft power of the core gas turbine, or to drive an electric generator to power auxiliary systems.

Phase I: Select a suitable intercooled gas turbine cycle. Develop bottoming cycle methods/concepts and predict thermodynamic performance of the overall system via computer modeling. Perform preliminary sizing studies and prepare preliminary drawings showing the integration of the gas turbine and the bottoming cycles. Select a preferred system and prepare detailed plan for Phase II effort.

Phase II: Construct a bread board demonstration unit using existing hardware to the maximum extent possible. Verify predicted system performance, size, weight, and volume.

Potential Commercial Market: An intercooled gas turbine engine with a compact, efficient bottoming cycle has unlimited commercial application potential for transportation (land, sea, air), power generation, and industrial processes. Large fuel cost savings will be the biggest benefit, brought about by greatly increased fuel efficiency.

TOPIC: A94-068TITLE:Low Cost Rejuvenation of Thermal Fatigue in Metal Matrix Composite Material
Point of Contact: AVRDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop techniques and procedures to demonstrate the feasibility of damage recovery in metal matrix composite materials.

DESCRIPTION: Historically, material such as turbine disk and compressor disk have been fabricated from high temperature nickel base super alloy and directionally solidified alloys (DS). As these alloys are used in service, they accumulate thermal fatigue and creep fatigue type of damage. Many programs to date have been initiated to assess the magnitude of the damage that accumulates during service and to retire these disks for cause or otherwise using various safety criteria for this purpose. Many of these disks are warehoused at a great cost for later use where safety measures may not be as severe. A situation such as a national emergency would constitute a typical application. Concurrently, light weight high strength fiber reinforced composite materials have a possible application to replace these alloys in the turbine and compressor disk areas. It is the intention of this project to develop techniques and procedures that will allow the "safe reuse" of the fiber reinforced composite disks without the need for a high dollar rework or a high dollar storage cost.

Phase I: Develop and demonstrate the feasibility of concepts and techniques for use in the rejuvenation of metal matrix composite material that contain classical creep/fatigue and ratchet-strain types of damage.

Phase II: Develop and deliver prototype techniques and demonstrate the cost effectiveness and performance effectiveness of the use of these techniques on prototype specimens fabricated from a standard MMC material such as Ti-6-4/SCS-6 in use today.

Potential Commercial Market: Results will be applicable to future high tech uses such as propellers, impellers, turbine applications of all types such as disk, bearing supports, shafting, etc. Cost saving potential is enormous.

TOPIC: A94-069TITLE:Low Cost, Hot Gas Throttling Valve, for Solid Fuel Based, Expendable, Tactical Missile Propulsion Systems
Point of Contact: MICOM

CATEGORY: Exploratory Development

OBJECTIVE: Development of a low cost, hot gas throttling valve, for solid fuel based expendable, tactical missile propulsion systems.

DESCRIPTION: Traditionally, tactical missile systems have exclusively utilized solid rocket propulsion. However, the mission requirements of the next generation of tactical missiles will demand a level of propulsion system flexibility that can not be met with a standard solid rocket. On-demand thrust control will be required, which will dictate the use of non-traditional solid propellant based propulsion systems such as: ducted rockets, hybrid rockets, and Air Turbo Ramjets (ATR). The solid fuel variants of these propulsion cycles employ a fuel rich gas generator as the fuel source. To obtain high performance (thrust), the gas generators of these systems must operate at relatively high maximum chamber pressures (up to 7000 psig) and temperatures (up to 2500 degrees F) levels. In addition, to provide thrust control (throttling), the mass flow rate of the gas generator must be modulated over a wide range (up to 10:1 turn down ratio). Finally, the flow rate modulation must be available on demand and under computer control.

To successfully develop high pressure, high performance, throttleable, solid fuel tactical propulsion systems, an on-demand throttling device is required. Thrust control of each respective engine can be effectively achieved through modulation of the gas generator fuel flow rate with a hot gas throttling valve. Consequently, technology is required for the development of low cost, light-weight, hot gas valves that can be utilized in the next generation of Army tactical throttleable solid propellant systems. The valves to be developed must incorporate the following features: compatibility with common gas generator solid propellant (e.g. AP/HTPB, GAP/C), flow rate insensitivity to downstream pressure fluctuations, maximum linearity over operating range, minimal hysteresis, 5:1 flow rate turn down ratio (10:1 desired), minimum 5000 psi chamber pressure (7000 psig desired), minimum 2500 degree F chamber temperature (3000 deg F), minimum 60 sec full throttle operation, rapid actuation (minimum to maximum flow rate in less than 100 msec), functionality with metalized fuels, low cost design consistent with tactical missile systems, minimized weigh t, minimized volume, electrical activation (analog or digital), continuum of on-demand available flow rates, self-contained sensors and feed-back control (if required), 10 year shelf-life, compatibility with tactical missile environment (storage transportation, and operating), compatible with microprocessor control, adaptability to a wide range of engine cycles and configurations. The system must take advantage of the expendable, short duration mission of tactical missiles to minimize cost and reduce weight and volume. Use of commercial (not aerospace) grade components are desired. The valve should employ generic technology and should be scaleable to accommodate a wide range of maximum flow rate (.1 to 50 lbm/sec).

Phase I: Under the Phase I effort, a heavy-weight, high pressure hot gas valve shall be designed, developed, fabricated, and demonstrated. This system shall be sized and designed for integration and operation with the MICOM Propulsion Directorate sub-scale direct-connect ducted rocket test facility. The sub-scale gas generator has a maximum chamber pressure of 3000 psig, a chamber temperature of 2000 deg F, a mass flow rate of 1 lbm/sec, a burn time of 30 sec, and a nominal O.D. of 5 in. Specific details of the MICOM sub-scale test hardware shall be provided after contract award. The device should incorporate as many of the desired features as possible. The contractor may demonstrate the system utilizing cold gas or inert hot gas. The demonstration must include some form of control system (preferably P.C. based) that can be employed to demonstrate on-demand flow rate control. At the completion of the effort the device must be delivered to the Government with any associated test hardware, control hardware and software (including source code) for independent experimental direct-connect evaluations utilizing a solid fuel gas generator and a ducted rocket combustor. Adequate spare and/or expendable valve components must be delivered to support a minimum of 5 hot gas tests.

Phase II: Under the Phase II effort a flight weight system shall be designed, developed, fabricated, and demonstrated that incorporates all the desired features. The maximum flow rate and final configuration shall be determined from an analysis of Army tactical missile system requirements. The final design shall be experimentally evaluated under the effort, over a wide range of conditions (transportation, storage, operational). Several devices shall be delivered to the Government for independent evaluation.

Potential Commercial Market: There are significant Military applications for this technology. This technology is an essential (enabling) element in the development of the next generation of high performance, mission-flexible/adaptable tactical missile systems. This technology will provide significant advances in tactical missile propulsion, consequently the market potentials is large. From a civilian perspective, commercial space launch vehicle could be developed that utilize this low cost tactical missile propulsion technology to significantly reduce acquisition and operating costs.

TOPIC: A94-070TITLE:High Efficiency, Low Cost & Weight Heat Exchanger for Gas Turbine Engines
Point of Contact: TACOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop materials and fabrication techniques for low cost, high temperature recuperator for advanced gas turbine engines.

DESCRIPTION: Recent advances in gas turbine engines resulted in high pressure ratios and high turbine inlet temperatures. To improve the fuel economy of these engines to the level comparable to the advanced diesel engines, recuperator technology has to be developed to withstand temperatures in the range of 1600-1800 F and higher if possible. Current recuperator technologies involve significant labor for fabrication resulting in high cost of recuperated gas turbine engines. Such high costs make the gas turbine unacceptable for application in the nonmilitary ground vehicles. The future technologies should address the cost issues. The weight and volume of the power plant are significant factors in its selection for application in ground vehicles. Hence, a smaller and lighter recuperator with good performance characteristics would enhance the acceptability of gas turbine engines for application interrestrial vehicles.

Phase I: Identify the materials and manufacturing processes to fabricate high performance, low costs and , low weight and volume recuperators.
Phase II: Procure materials and fabricate a laboratory prototype recuperator and demonstrate its performance.

Potential Commercial Market: Currently the automotive companies are evaluating the gas turbine engines for application in the hybrid vehicles. The future emission standards may force the use of low emission engines, like gas turbines, in the passenger vehicles. The potential for the application of gas turbine engines in the marine and commercial vehicles is also high.

A-6POWER AND DIRECTED ENERGY

TOPIC: A94-071TITLE:Extremely Lightweight Hydrogen Fuel Cells
Point of Contact: E&PSD

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate an extremely lightweight fuel cell stack.

DESCRIPTION: Future man-portable power supplies (approx. 300 watts and ≤5kG) will necessarily involve lightweight, high power density fuel cell stacks. Current fuel cell designs utilize polymer electrolyte membranes (PEM) in a bipolar arrangement where the cathode of one cell is electrically connected to the anode of its neighbor. Since fuels/oxidants delivered to anodes/cathodes must be physically separated in order to prevent mixing, there is considerable weight, cost, and engineering complexity in present fuel cell systems. In addition, the entire assembly must be firmly bolted together thus adding considerable weight for end plates and bolts. It would be desirable to design

a fuel cell system where much of the system weight is eliminated. One possible arrangement could involve minimizing the weight of the materials used in constructing bipolar fuel cell stacks. Another approach could involve elimination of the bipolar configuration entirely by using a single polymer electrolyte membrane (PEM) sheet as the proton conducting electrolyte for a number of individual fuel cells. Fuel and oxidant would be delivered to opposite sides of the sheet which would be shared and utilized by all cells within the fuel cell stack. Individual fuel cells would be created by forming electrically conducting zones alternating with electrically insulating zones contained within the PEM electrolyte itself. Since the large PEM sheet is used to isolate and define individual cells, thermal and water management problems are minimized.

Phase I: Should result in a lightweight, small size, prototype fuel cell stack and/or a conceptual design for a complete fuel cell system where either extremely lightweight construction materials are used or, alternatively, a nonbipolar arrangement is used. The operating fuel cell must consist of at least three individual cells. The scaled up version of the design should result in approx. 300 watt fuel cell system weighing ≤5kG.

Phase II: Will result in construction of approx. 300 watt fuel cell stack with the minimum possible weight.

Potential Commercial Market: Lightweight fuel cells should have direct applications in portable power applications such as electric vehicles and various electronic devices.

TOPIC: A94-072TITLE:High Frequency Alternator, Power Frequency Conversion (HFA-PFC) Technology for Lightweight Tactical Power Generation

Point of Contact: CECOM

CATEGORY: Advanced Development

OBJECTIVE: To explore the potential for generator set size and weight reduction through the use of integrated power components. Components include a lightweight, High Frequency Alternator (HFA) coupled with Power Frequency Conversion (PFC) components to produce MIL-STD power (such as 60 Hz, 120 VAC). A control system would maintain the proper output frequency and voltage for transient and steady state load conditions and changing engine speed.

DESCRIPTION: There exists excellent potential for reducing the size and weight of DOD tactical generator sets using the HFA-PFC concept. In addition to potential weight reductions, this concept de-couples the output frequency from engine speed so that the engine can run at a speed dictated by the operational environment (higher speeds for maximum power or lower speeds for maximum fuel efficiency and reliability). Such performance flexibility and size/weight reductions would improve the operational performance of the gen- sets due to improved deployability and mobility, and reduced handling requirements. Such performance goals match Army requirements and scenarios for highly dynamic "shoot and scoot" situations expected in future conflicts. A weight driver for current DoD gen-sets is the 60 Hz alternator which is generally driven at 1,800 rpm by the engine. Alternator size and weight decrease dramatically when speed and frequency are increased. Engine power density can also be increased because the engine can be run at its optimum power speed for high power loads. The PFC components condition alternator power to produce MIL-STD frequency and voltage (such as 60 Hz and 120 VAC) independent of engine speed. Commercial 1,800 rpm, 60 Hz alternators represent static technology with little performance improvements foreseeable. Power semiconductors (the major component of the PFC) are a rapidly advancing technology with excellent potential for further size/weight reductions in the future.

Phase I: The contractor shall determine optimum HFA-PFC design options for the following power ranges: 5-30 kW, 30-100 kW and 100-1,000 kW. Determine the optimum HFA design and the optimum power semiconductor technology and topology for the given power ranges.

Phase II: The Government can determine the optimum power range(s) to be explored during Phase II based on Phase I results analysis and review.) The contractor shall fabricate and test prototype full scale or sub-scale (as appropriate) versions of the HFA-PFC. The mobility and deployability benefits due to weight reductions shall be

quantified along with studies to determine producibility and logistics issues associated with HFA-PFC based gen-sets.

Potential Commercial Market: HFA-PFC technology would be applicable to the commercial gen-set market segments where size/weight and/or fuel efficiency are key concerns. The major life cycle cost element of commercial gen- sets is fuel cost, so being able to produce 60 Hz at the most efficient engine speed could be a distinct advantage.

A-7 BIOTECHNOLOGY

TOPIC: A94-073TITLE:Recombinant Antibodies for Chemical/Biological Warfare (CBW) Detection
Point of Contact: ERDEC

CATEGORY: Exploratory Development

OBJECTIVE: To design recombinant antibodies for detecting CBW agents and to develop expression systems for their scale-up production.

DESCRIPTION: The Army has a requirement to develop antibodies for sensors and test kits for detection of pathogens, toxins and chemicals. The current approach is based on well known hybridoma technology and, while successful, has several drawbacks. Time required to develop a particular antibody is long, impeding the Army's ability to quickly respond to new threats; production is relatively expensive; hybridoma cell lines are often unstable; it is not possible to design antibodies with particular binding characteristics.

Phase I: The objective is to demonstrate the ability to develop a phage display selection system, construct an immunoglobulin gene library and select specific antigen binding clones. A plan for selection, mutation and expression of high affinity clones in a bacterial system will be described for successful transition to Phase II.

Phase II: Two objectives will be pursued for Phase II. Parameters for scale-up of the bacterial expression system to at least 30 L will be defined and demonstrated, and antibody yields will be optimized. Second, specific antigen binding peptide fragments will be developed from existing cDNA libraries without using immunized animals.

Potential Commercial Market: The products and processes developed from this project will have widespread applications in environmental monitoring (e.g., pesticides in soil and ground water), industrial processes (e.g., test kits) and agriculture (e.g., antibiotics in milk). Pharmaceutical firms usually contract out for their antibody needs and this technology will confer many advantages in speed and cost to the developer.

TOPIC: A94-074TITLE:Self-Organizing Biomolecular Materials as Structural and Patterning Elements for Device Fabrication
Point of Contact: ARO

CATEGORY: Basic Research

OBJECTIVE: Characterize process and product for self-assembling, pattern-forming biological macromolecular array.

DESCRIPTION: A number of complex biological macromolecules offer appealing potential for their ability to self-assemble at the nanometer level in two-dimensional crystal lattice layers on surfaces, or as reproducible uniform three dimensional structures in solution or on surfaces. This new class of biomolecular materials comprises various combinations of proteins and lipids, for the most part, and in some cases includes complex carbohydrate molecules. Because the distribution and orientation of their associated functional groups are in both cases precisely defined, they serve as structural and patterning elements for fabrication of new generation optical and electronic devices, for separation technology, or for other advanced-concept materials. Basic research is needed to better understand

self-organizing processes in nature and to learn how we might be able to more fully utilize the underlying principles, exploit the process, and incorporate the product, as biological or biomimetic components, for synthetic application.

Phase I: Identify and characterize self-organizing biomolecular system and provide description of synthetic and processing pathways involved in elaboration of final functional product by cell.

Phase II: Describe the manner in which biological material structure at the molecular level is a determinant of macroscopic pattern formation. Provide means for manipulation of system via molecular genetic, biochemical and/or biophysical modification, permitting purpose-built design changes with potential for use as device elements.

Potential Commercial Market: The potential for fault-free manufacture of important electronic, photonic or other arrayed device components, highly ordered at extremely small dimensions, using biological or biologically-derived templating methods, is very high. With improved understanding of how complex nanometer scale biological structures are fabricated via self-assembly in nature, there should be substantial commercial interest in further development and application of the technology.

TOPIC: A94-075TITLE:Development of Biosensor and Assays for the Detection of BW Agents Using Fluoresceinated and Biotinylated Antibody and Nucleic Acid Probes
Point of Contact: MEDICAL

CATEGORY: Basic Research

OBJECTIVE: Develop or modify a preexisting biosensor device to enable detection of BW agent specific antigens or extracellular products and toxins using biotinylated and fluoresceinated "capture" and "detection" antibodies, at picogram or sub-picogram levels, from biological fluids.

DESCRIPTION: The developed or modified biosensor must also be capable of detecting amplified BW agent specific nucleic acids which are liquid hybridized with fluoresceinated and biotinylated probes from biologic fluids. The system must be simple, sensitive and rapid for field use. The system must be applicable to biologic fluids such as blood, urine, saliva and diarrheal stools. Biologic agents and toxins to be detected by the antigen capture and PCR methodologies include anthrax, plague, tularemia, cholera, VEE ricin, Staph enterotoxins, botulinum toxins and saxitoxin. Monoclonal and polyclonal antibody reagents and specific PCR primer sets and probes will be provided for use in the development biosensor assays.

Phase I: Design a system for field use capable of detecting picogram and sub-picogram levels of a single BW agent specific antigen or toxin by antigen capture and by detection of liquid probe hybridized PCR amplified nucleic acids.

Phase II: Develop assays for other BW agents and toxins and evaluate system against other established diagnostic methods using clinically relevant specimens.

Potential Commercial Market: Several BW agents and toxins that pose a military threat are also significant public health hazards in the US and throughout the world. This system and developed assays would be of great value in determining causes of undetermined infectious diseases and food poisoning and could be used in hospital laboratories or physicians' offices.

A-8 LIFE, MEDICAL AND BEHAVIORAL SCIENCES

TOPIC: A94-076TITLE:Adaptive Display of Critical Battlefield Information for the Individual Commander
Point of Contact: HRED

CATEGORY: Exploratory Development

OBJECTIVE: Using natural language processors and rule based systems, develop an automatic alert and display structure for the commander based on his individualized model of the battlefield tactical environment.

DESCRIPTION: Fast moving battles similar to the situation in southwest Asia result in the commander outpacing his battle information. Modern information systems such as Tactical Information Broadcast System (TIBS), Common Ground Station (CGS), Intra-vehicle Information System (IVIS), and All Source Analysis System (ASAS) ensure the commander a plethora of battlefield information during the actual battle. If all the information was forwarded to him, not only would the commander be overwhelmed, but his staff would be inundated as well. Smart filters are needed to automatically extract the critical information for the commander and ensure its timely display. The problem is multifaceted; it requires a thorough understanding of the cognitive requirements of the commander as well as intelligent software that can interpret the commander's requirements. Research at ARL (Warner, 1993) indicates that the type and format of information the commander requires is highly dependent on his tactical decision task. This suggests that two related problems need to be solved in conjunction with an adaptive information filtering system. The first involves research in how to capture the commander's mental model as critical information is being received during the heat-of-battle. The second problem is how to produce artificially intelligent software that extracts battle critical information for the commander. Simply extracting information from multiple information sources could easily result in a mismatch between the commander's ongoing decision processes and the display of the current battle situation. In fact, the commander's information requirements are likely to be highly individualized and to change as a function of where he is in the battle. The filters must act as a "pull" system and be intelligent enough to adapt to individual commanders as well as adapt to the changing information environment.

Phase I: The initial effort will demonstrate adaptive logic for filtering battlefield information. The adaptive logic must be based on individual commanders inputs and be able to change as function of battlefield conditions. The first phase shall demonstrate that a subject matter expert's (SME) information requirements, preferred formats, and changing tactical priorities could be represented in software to serve as the criteria for an adaptive filter and display system. The criteria would set filter parameters which automatically parse incoming intelligence and battlefield information for high value information. The culmination of Phase I is a demonstration of an adaptive information system that filter incoming data and display the type and format of information based on the individual commander's preference structure.

Phase II: The second phase will demonstrate individualized software modules that can be easily programmed by military operators. Using simulation experiments, advanced natural language processors, and cognitive engineering technology, a practical interface environment for the commander will be designed. The interface shall define the commander's requirements for battle management and shall be easily implemented as part of the planning process. The interface an d underlying software shall be rapidly prototyped and rigorously tested in field and realistic simulation exercises to evaluate the concepts in near operational environments.

Potential Commercial Market: The potential market would be high volume banks, stockbrokers, and large scale inventory control systems--any industry that is inundated during peak business hours. "Smart" filters which identify messages that must be responded to immediately has a high commercial value of decreased cost and increased effectiveness. Information processing systems based upon intelligent filters will be the next revolution in information technology.

TOPIC: A94-077TITLE:Representing and Analyzing Mental Models
Point of Contact: ARI

CATEGORY: Exploratory Development

OBJECTIVE: To develop and validate a rapid means of representing an individual's mental model of a battlefield situation and of inferring the knowledge structures that underlie it.

DESCRIPTION: The development of concept maps to represent an individual's understanding of the entities and relationships involved in a complex situation is a lengthy, highly interactive process. As such, it is not particularly useful in naturalistic decision-making research where the mental models are very dynamic and interaction with the researcher alter the decision-making process. Yet prior research on decision-making and problem solving expertise has shown that problem representation is a key aspect of this expertise. Also, if there w as a rapid means of externally representing mental models, it who greatly enhance the building of shared understandings. A related research problem is inferring the knowledge structures that underlie the mental model. Our interpretations of the external world are based on the interaction of goals with our knowledge of the objects and relationships involved in the problem situation and task. What a subject typically conveys in a problem solving protocol is the interpretation (i.e, mental model). The reasoning involving the underlying knowledge structures may never reach conscious awareness, especially if the subject is an expert. We need a reliable means of inferring those knowledge structures from resulting mental models.

Phase I: Phase I will involve the identification and evaluation of means of rapidly representing mental models. The expected result is the selection of two methods to be tested in Phase II.

Phase II: Phase II will begin with final selection, development and validation of a method. Subsequent work will involve research into inferring underlying knowledge structures from mental models and applying the method to groups in the development of shared mental models.

Potential Commercial Market: A user-friendly means of externalizing the reasoning behind management decisions and conveying it to others will have wide application in a variety of organizations.

TOPIC: A94-078TITLE:Develop Lightweight, Portable, Non-invasive Physiologic Sensors for Multi-site Determination/Quantitation of Surface and Deep Tissue Oxygenation

Point of Contact: MEDICAL

CATEGORY: Exploratory Development

OBJECTIVE: To non-invasively measure (at multiple sites) the oxygenation of deep tissues (e.g., large muscle masses). The sensor must be capable of interface with standard computer input ports, in order to record, store and eventually transmit the oxygenation status data.

DESCRIPTION: There is a growing need for sophisticated biochemical and physical sensors to monitor the physiologic status of casualties on the battlefield. Monitoring of this type will augment current abilities to diagnose and triage trauma victims, and to evaluate tissue oxygenation and/or areas of tissue hypoxia during evacuation (transport), as well as during stabilization, resuscitation and treatment. Such sensors should collect desired information rapidly and reliably, and interface with both real-time display devices and data storage devices of standard computers. Currently-described sensors must be capable of sampling multiple sites simultaneously, and acquire data on deep-tissue (e.g., skeletal muscle) oxygenation.

Phase I: Produce prototype components for such a system from existing or novel materials, capable of demonstrating the proof-of-principle.

Phase II: Integration of all components into a pre-production prototype. Demonstrate the features and capability of the prototype in tissues simulating battlefield hemorrhage and shock.

Potential Commercial Market: The use of such physiologic sensors is anticipated not only under battlefield conditions, but also in a variety of emergency medicine scenarios, including: emergency response teams (both urban and rural), hospital emergency rooms, surgery, intensive care and coronary care suites, etc.

TOPIC: A94-079TITLE:Lightweight, Portable, Non-invasive Physiologic Sensors for Multi-site Determination/Quantitation of Surface & Deep Tissue Microvascular Blood Flow

Point of Contact: MEDICAL

CATEGORY: Exploratory Development

OBJECTIVE: To non-invasively measure (at multiple sites) the microvascular blood flow of deep tissues (e.g., large muscle masses). The measurement must be similar in signal or design to current laser doppler technology. The sensor must be capable of interface with standard computer input ports, to record, store and eventually transmit the oxygenation status data.

DESCRIPTION: There is a growing need for sophisticated biochemical and physical sensors to monitor the physiologic status of casualties on the battlefield. Monitoring of this type will augment current abilities to diagnose and triage trauma victims, and to evaluate tissue oxygenation during evacuation (transport) and/or stabilization, resuscitation and treatment. Such sensors should collect desired information rapidly and reliably, and interface with both real-time display devices and data storage devices. Currently-described sensors must be capable of sampling multiple sites simultaneously, and acquire data on deep-tissue (e.g., muscle) oxygenation.

Phase I: Produce prototype components for such a system from existing or novel materials, capable of demonstrating the proof-of-principle.

Phase II: Integration of all components into a pre-production prototype. Demonstrate the features and capability of the prototype in tissues simulating battlefield hemorrhage and shock.

Potential Commercial Market: The use of such physiologic sensors is anticipated not only under battlefield conditions, but also in a variety of emergency medicine scenarios, including: emergency response teams, hospital emergency rooms, surgery, intensive care and coronary care suites, etc.

TOPIC: A94-080TITLE:Develop Lightweight, Portable, Non-invasive Physiologic Sensors for Multi-Determination and/or Quantitation of Surface and Deep Tissue pH

Point of Contact: MEDICAL

CATEGORY: Exploratory Development

OBJECTIVE: To non-invasively measure (at multiple sites) the acid-base status (pH) of deep tissues (e.g., large muscle masses). The sensor must be capable of interface with standard computer input ports, in order to record, store and eventually transmit the oxygenation status data.

DESCRIPTION: There is a growing need for sophisticated biochemical and physical sensors to monitor the physiologic status of casualties on the battlefield. Monitoring of this type will augment current abilities to diagnose and triage trauma victims, and to evaluate tissue pH following trauma and/or shock during evacuation (transport), as well as during stabilization, resuscitation and treatment. Such sensors should collect desired information rapidly and reliably, and interface with both real-time display devices and data storage devices of standard computers. Currently-described sensors must be capable of sampling multiple sites simultaneously, and acquire data on deep-tissue (e.g., muscle) pH.

Phase I: Produce prototype components for such a system from existing or novel materials, capable of demonstrating the proof-of-principle.

Phase II: Integration of all components into a pre-production prototype. Demonstrate the features and capability of the prototype in tissues simulating battlefield hemorrhage and shock.

Potential Commercial Market: The use of physiologic sensors is anticipated not only under battlefield conditions, but also in a variety of emergency medicine scenarios, including: emergency response teams (both urban and rural), hospital emergency rooms, surgery, intensive care and coronary care suites, etc.

TOPIC: A94-081TITLE:Establishment of Methods for Determining Gene Function in the Malaria Parasite

Point of Contact: MEDICAL

CATEGORY: Exploratory Development

OBJECTIVE: Develop methods for establishing the functionality of genes in Plasmodium sporozoites.

DESCRIPTION: The recent success of DNA transfection in several protozoan parasites suggests that these methods will also be applicable for screening the functionality of genes in the malaria parasite with the aim of defining candidate molecules for vaccine development or the development of attenuated which could themselves be used as a vaccine.

Phase I: Development of transfection protocols to allow both the transient and stable expression of genes introduced into Plasmodium sp., with emphasis on Plasmodium sp. sporozoites.

Phase II: Assess the status of transfected DNA in Plasmodium with regard to recombination, chromosomal integration, and targeted gene replacement. Develop methods to screen genes for function and to determine whether targeted genes are essential for parasite viability or infectivity, with emphasis on the sporozoite or liver stages.

Phase III: Screen genes for function.

Potential Commercial Market: Immunization with radiation-attenuated sporozoites protects human subjects from malaria, and natural exposure to malaria induces immune responses that dramatically reduce the morbidity and mortality associated with malaria. However, the parasite proteins which elicit these responses are not known. A company that develops methods for identifying gene function in Plasmodium will be in the unique position to target promising gene products for vaccine development.

TOPIC: A94-082TITLE:Gene Transfer Vectors for Malarial Genes
Point of Contact: MEDICAL

CATEGORY: Exploratory Development

OBJECTIVE: To develop nucleic acid vectors to carry malarial genes across red blood cell membranes, parasitophoresis vacuolar membranes and parasite membranes that allow insertion of DNA into the parasite genome.

DESCRIPTION: It is presently impossible to transfer genes into the Plasmodium falciparum malarial genome. The stages of the parasites development that exist outside the host cell are not amiable to experimental manipulation. Those stages that exist inside host cells have an elaborate array of membranes between the parasite's nucleus and the outside of the cell. In order to do modern genetic analysis of parasite genes the technique of gene transfer must be developed. Standard methods of gene transfer have not been successful. It is hoped that natural DNA or RNA vectors that have the ability to cross membranes can be used to deliver genes into the parasite's nucleus. Vectors must be able to be used in BL1 or BL2 conditions set out by the Recombinant DNA Advisory Committee (RAC).

Phase I: Experimental development of vectors containing malarial promoter sequences and detector genes such as luciferase, beta-galactosidase or neomycin. Testing of these constructs to delivery genes to developing parasites in red blood cells.

Phase II: Construction, in conjunction with the Walter Reed Army Institute of Research, of vectors containing malarial genes and genetic analysis of specific genes in the parasite by either replacement or interruption of gene sequence.

TOPIC: A94-083TITLE:Cellular Immune Response to Diseases of Military Importance
Point of Contact: MEDICAL

CATEGORY: Basic Research

OBJECTIVE: To develop new, sensitive, quantitative tests to monitor cellular immunity as a response to vaccinations.

DESCRIPTION: Recovery from, protection against and perhaps the disease process itself, of several diseases of military importance are mediated by cellular response or immunity. Sensitive, quantitative, and easily applied tests to detect relevant responses are needed both in evaluation of the immune status of antibody-negative subjects and to monitor the disease process and vaccine development. Typical systems in which such responses are thought to be biological relevant include diseases caused by Q-fever, filoviruses, VEE, ricin and the staphylococcal enterotoxins.

Phase I: Develop an assay to aid in evaluation of the immune status of antibody-negative subjects and to monitor the disease process and vaccine development for one agent of interest.

Phase II: Show the utility of immuno assay(s) for other classes of agents of interest.

Potential Commercial Market: Monitoring cellular immunity may be used to evaluate immune status of antibody-negative individuals vaccinated against a variety of infectious diseases. Development of a sensitive quantitative test of cellular immunity would be of potential interest to all vaccine manufacturers in order to quantify levels of protection demonstrated by a new or existing vaccines.

TOPIC: A94-084TITLE:Delivery of Vaccines by Biodegradable Polymeric Microcapsules with Bioadherence Properties
Point of Contact: MEDICAL

CATEGORY: Basic Research

OBJECTIVE: To demonstrate the feasibility of biogradable microspheres for the encapsulation of vaccines with or without immunoadjurants which would evoke complete protection for a duration of at least one year by single administration.

DESCRIPTION: To achieve maximum protection, most vaccines require two or three booster doses, causing logistical difficulties. Furthermore, parenteral administration of the vaccine by trained medical personnel considerably increases the cost of vaccination. Therefore, biodegradable microspheres for the encapsulation of vaccines with or without immunoadjuvants are needed which would evoke complete protection for a duration of at least one year by single administration. Toxins of principal interest include ricin, microcystin, botulinum toxin, saxitoxin and staphylococcal enterotoxins, clostridial perfringens toxins as well as other low molecular weight, peptide, and protein toxins. Infectious agents of interest include anthrax, plague, tularemia and selected virus diseases (e.g. VEE).

Phase I: Demonstrate feasibility in laboratory animals, using a vaccine against agents listed above.

Phase II: Extend to include preclinical trails to support in submission.

A-9ENVIRONMENTAL AND GEOSCIENCES

TOPIC: A94-085TITLE:Development of Non-Toxic Cores for Small Caliber Projectiles
Point of Contact: ARDEC

CATEGORY: Exploratory Development

OBJECTIVE: To utilize state of the art polymer technology to develop high density, metal injection molded polymer compounds having the required characteristics for an effective and functional projectile/core. The result will demonstrate the application of cost effective, lead-free environmentally safe alternate materials for small arms

ammunition.

DESCRIPTION: The successful development of two small caliber ammunition rounds, the type classified Caliber .50 saboted light armor penetrator (SLAP) and the 7.62mm short range training ammunition (SRTA), was due to recently developed engineered polymer resins. The SLAP utilizes a polyetherimide, PEI resin while the 7.62mm SRTA consists of a high density, 85% bronze filled nylon-11 material. Both are high temperature, high performance type engineered resins. Further development in the area of high performance polymer compounds could result in the identification of a material suitable for application in small arms ammunition projectiles. The development of this material would result not only in lower projectile costs due to the fact that the time consuming and costly practice of removing lead from practice ranges and lead dust from processing areas will no longer be required. In addition, various starches and other proven biodegradable additives can be incorporated in the polymer resin resulting in a non-toxic material that will decompose completely in water or soil leaving no synthetic or toxic residues. The metal injection molded projectile development program will utilize high density, metal injection molded compounds of fine metal powders in a polymeric binder. Metal materials would include bronze, stainless steel, copper, and/or aluminum. Specific gravities of 6.0 grams/cc have already been achieved with copper filled polymer compounds and it is estimated that specific gravities of 10-12 grams/cc (steel is approximately 8 grams/cc while lead is approximately 11.5 grams/cc) can also be achieved with additional research. Alloys of these materials will also be used in order to control the cost and physical properties of the material such as specific gravity, compressive/tensile strength and elongation. These materials will be engineered to provide the characteristics required of small arms ammunition with the 7.62mm M80 cartridge serving as the test bed for this development.

Phase I: During the initial development effort the properties of existing polymer compounds will be analyzed to determine the effects of various alloying materials on the physical properties of the compound. In addition, a literature search will be conducted to determine the toxicity of the candidate materials. A matrix of required and desired material properties for the polymer projectile core will then be generated. This information will form the basis for the development of several candidate polymer compounds. The contractor will then mold polymer projectile cores using the developmental compounds. The cores can either be molded directly in the existing metal projectile jackets or molded separately and later inserted into the jacket.

Phase II: The prototype projectiles will be delivered to ARDEC for ballistic test and evaluation to determine their safe and effective use in 7.62mm M240/M60 series machine guns as well as any effects on projectile flight characteristics due to the core material. It is anticipated that several iterations of development, fabrication, test and evaluation will occur during this effort. If this material/projectile is successful in 7.62mm applications, expanded applications can be investigated: e.g. 5.56mm, 9mm and .50 caliber ammunition.

Potential Commercial Market: The technology developed under this program can be utilized by all commercial manufacturers of small arms ammunition. Currently, there is a great deal of concern in the private sector over the contamination of shooting range s due to high lead content. For the armed services, the development of a non-toxic alternate material projectiles would allow continued training on ranges that are currently in danger of being closed due to the high levels of lead contaminants in the surrounding areas. In order for both the military and public ranges to remain open, costly clean-up procedures that provide only a temporary solution are required. Use of the alternate material projectiles will allow the soldiers to continue training on existing ranges, thereby enhancing their combat effectiveness, without the associated range clean-up expenses.

OSCRS: This technology will provide cost reductions over the entire life cycle of the ammunition. Full scale production costs will be substantially reduced and costs associated with the decontamination and clean up of firing ranges will be virtually eliminated. Other benefits include improved product uniformity and improved ammunition accuracy as well as the identification of an alternate lead free material for small arms projectile s.

TOPIC: A94-086TITLE:Environmental Interaction for EOSAEL
Point of Contact: BED

CATEGORY: Exploratory Development

OBJECTIVE: Interface individual EOSAEL modules with WINDOWS on CD ROM for use on 486 and equivalent PCs.

DESCRIPTION: The Environmentally Oriented Systems Atmospheric Effects Library (EOSAEL) is a state-of-the-art computer library comprised of fast-running, theoretical, semi-empirical, and empirical computer programs (called modules) that mathematically describe various aspects of electromagnetic propagation in the ultraviolet, visible, near-, mid-, far-infrared, and millimeter wave for battlefield environments. The modules address transmission through both the natural environment and through man-made obscurants which are common on the modern battlefield. The modules are engineering oriented with the philosophy to give reasonably accurate results with the minimum in computer time for conditions that may be expected on the realistic battlefield. EOSAEL contains twenty-five modules dealing with various aspects of atmospheric propagation that deal with degradation of target signatures. Placing EOSAEL on CD ROM running under WINDOWS would allow for the easy examination of atmospheric effects by soldiers and civilians alike.

Phase I: Develop a plan to interface all EOSAEL modules with WINDOWS and provide a prototype for the EOSAEL COMBIC (Combined Obscuration Model for Battlefield Induced Contaminants) module. Plans for front ends for each of the twenty-five modules must be developed along with icons for each of the individual modules. In addition to placing the prototype COMBIC module on CD ROM implemented under WINDOWS, this plan will show how all of the EOSAEL modules will reside on CD ROM running under WINDOWS for easy use on 486 and equivalent PCs.

Phase II: Development of a software package based on the development plan in Phase I. This software package shall reside on CD ROM and will run all EOSAEL executables on 486 PCs and equivalents under WINDOWS. The potential EOSAEL WAVES (Weather and Atmospheric Visualization Effects for Simulation) suite of four codes shall also be included. Context sensitive help using the WINDOWS help facility shall be employed for all modules. Documentation shall be provided in WordPerfect format in a collective document explaining how to run the modules under WINDOWS.

Potential Commercial Market: A large potential commercial market exists in the application of these modules to civilian projects: laser communication, determination of vehicular-raised dust pollution, light (broadband and laser) attenuation through natural and man-made pollutants (fog, rain, snow, oil fires, etc.), dispersal of fire and smoke plumes, illumination levels under various cloud types, determination of scattered radiation levels, radar propagation, etc.

TOPIC: A94-087TITLE:Destruction of Military Relevant Chemicals and Wastes
Point of Contact: ARO

CATEGORY: Exploratory Development

OBJECTIVE: Detoxification of hazardous chemicals and chemical agents through the use of non-polluting destructive adsorbents.

DESCRIPTION: Because of the millions of pounds of military chemical wastes generated annually, there is a need for innovative technologies to destroy these chemical wastes. Destructive Absorption Technology (DAT) is a non-polluting treatment process that has been demonstrated to be theoretically capable of treating hazardous substances, including chemical warfare agents, chlorocarbons, and contaminated soil and debris while allowing for reclamation of valuable byproducts as fuels or feedstocks. DAT performance is dependent upon the synthesis and use of ultrafine (nanoscale), highly reactive metal oxides such as CaO and MgO as destructive adsorbents. Excellent results have been obtained in

the laboratory with specially prepared (by aerogel/hypercritical drying) metal oxides. However, for DAT to be commercially used, easier and less expensive methods for synthesis of the destructive adsorbents are necessary.

Phase I: New approaches to synthesis need to be addressed in Phase I. Surface areas need to be monitored and correlated with the destructive capacity using various stimulants and chlorinated solvents as substrates.

Phase II: A reactor design for large scale operation needs to be decided upon and a prototype will be built. Designing and testing of this prototype will be the main thrust of Phase II. Consideration should also be given to development of a portable or moveable system, which would be more useful at sites of relatively small amounts of contamination.

Potential Commercial Market: DAT has potential for use as a non-polluting, closed loop reclamation alternative to incineration for detoxifying hazardous wastes. It will be used by waste reclamation companies which typically offer solidification and incineration treatment services and sell landfill space for disposal of wastes and treatment residues. Other applications as air scrubbers are also likely.

TOPIC: A94-088TITLE:Destruction of Chemical Warfare Agents by Efficient Semiconductor Photocatalysis Under Solar Irradiation

Point of Contact: ARO

CATEGORY: Basic Research

OBJECTIVE: Develop photocatalytic system for efficient use under solar irradiation.

DESCRIPTION: The Army has a need for new and innovative technologies for destroying chemical stockpiles and chemical waste. A potential technology is semiconductor-catalyzed photooxidation. TiO2 photocatalysis has received considerable attention using both artificial and solar irradiation, however, because only about 1% of the solar spectrum is utilized by TiO2, photocatalysis is typically quite inefficient outdoors. Several approaches have been undertaken to extend the absorption of TiO2 into the visible region including doping TiO2 and sensitizing TiO2 by charge injection using dyes. Although improvements have been reported, a breakthrough leading to an efficient solar photocatalytic unit has not yet been realized. This announcement is looking for new and innovative approaches (which may/may not be related to those noted above) to developing an efficient solar photocatalytic system. Proposals are not limited to studies of TiO2.

Phase I: Carry out basic research which demonstrates the potential for significantly improved photocatalytic activity under solar irradiation.

Phase II: Construct a photocatalytic reactor and demonstrate efficient solar photocatalytic degradation of compounds of interest to the Army.

Potential Commercial Market: A successful solar photocatalytic system would received wide spread use as a low cost, low technology method for waste remediation. Some of the compounds that could be treated include PCBs, TCE, phenols, chlorine and nitrogen t containing aromatics, and pesticides. This technology would be of great interest to businesses which use solvents that require disposal, and chemical and pesticide manufacturers.

TOPIC: A94-089TITLE:Autonomous, Coherent Eye-Safe Lidar Wind Field Sensors

Point of Contact: ARO

CATEGORY: Basic Research

OBJECTIVE: To develop an autonomous, coherent eye-safe laser radar to detect hazardous wind conditions in the approach and departure ones for Army, DoD, and civilian aircraft. This device would operate in the clear air

(non-precipitating) conditions to enhance the all-weather detection of the conditions. The device must be capable of stand-alone minimal maintenance similar to millimeter or centimeter radar devices.

DESCRIPTION: Sensor systems using millimeter and centimeter wavelength radars have the ability to sense those wind field conditions which pose hazards to air traffic during landing or takeoff operations provided that the ambient atmosphere has sufficient moist, turbulent eddies. Under dry air conditions, millimeter wave (MMW) and microwave radars do not have sufficient sensitivity to detect dangerous aeronautical conditions. It is precisely under these clear air conditions that optically eye-safe lidars have the potential to detect and quantify aeronautically dangerous conditions. For an all weather capability, a combined lidar/radar system may well be required. What is needed is t he technology to make a coherent lidar system autonomous, capable of continuous calibrated operation at full sensitivity. In addition to the development of the necessary coherent lidar technology, algorithms for the fusion of the MMW and lidar data will have to be developed.

Phase I: Develop the design concepts necessary to produce an autonomous lidar system operating at eye-safe frequencies that is capable of detection of wind speed by the doppler shift. Design criteria should include principles that will eliminate the need for quasi-continuous human monitoring and intervention into the lidar operation, the data acquisition, and the data analyses.

Phase II: Develop a prototype wind sensing lidar and test the concepts identified in Phase I that will permit autonomous operation.

Potential Commercial Market: Should a reliable, semi-autonomous, all weather microburst detector be developed, every major airport in the world would be a potential buyer. A very large market exists for a proven system with adequate support.

TOPIC: A94-090TITLE:Real Time Monitor for Dangerous Air Emissions from Cleanup Sites
Point of Contact: CERL

CATEGORY: Exploratory Development

OBJECTIVE: To develop real time monitoring for dangerous air emissions at hazardous waste cleanup sites.

DESCRIPTION: At hazardous waste cleanup sites, worker protection is a critical issue. Air sampling for worker protection is dictated by NIOSH, while air sampling for community protection is dictated by the EPA. Typically workers take precautionary measures and don cumbersome clothing which renders their cleanup efforts inefficient and which seem to go well beyond the reasonable requirements of the job. It is the practice of both industry and government to overprotect workers. Laboratory analyses usually take too long to be of any use in making decisions for the upgrade or downgrade of worker protection. There is a need to determine in real time, the quantity and types of air emissions from sites that are being remediated so that worker protection can be adjusted accordingly. Parameters such as remediation techniques, the environmental conditions at the remediation site and worker exposure must all be investigated.

Phase I: Select typical air emissions released during remediation, which require monitoring. Evaluate real time monitoring possibilities for these air emissions and select the appropriate monitoring techniques for testing. Determine the relationship of emissions measured to environmental conditions such as weather, soil concentration, activity at the site, etc.

Phase II: Field test the real time monitoring methods at several sites to determine their usefulness.

Potential Commercial Market: There is currently no real time monitoring of air pollution emissions for worker protection. This information would be invaluable to the remediation industry for worker safety and protection.

TOPIC: A94-091TITLE:In-Situ Electronic Sensors to Determine Analytes in Cold-Regions Soils
Point of Contact: CRREL

CATEGORY: Basic Research

OBJECTIVE: To develop electronic sensor systems which can quantify C02 02, NH4+, NH3, and N03- concentrations in soil atmospheres and soil solutions at temperatures as low as -10 C.

DESCRIPTION: Many current and former DoD installations in cold regions have contaminated soil sites. Bioremediation and natural attenuation are promising cost-effective approaches to treating these sites, but their use is inhibited by our limited ability to make in-situ measurements of the effect of remediation treatments, naturally occurring processes, or both. For research and operational purposes, a clearer and more defined three-dimensional picture of changes in solution and vapor concentrations of contaminants, microbial substrates and their intermediates, and the sub-soil environment must be made and the data accessible from remote systems.

Phase I: 1.) Identify appropriate existing chemical or physical sensing mechanisms and need for new sensors. 2.) Develop prototype system using existing sensors and data-logging systems. 3.) Test prototype. 4.) Evaluate the feasibility of using state-o f-the-art sensor technology to address new capability needs.

Phase II: 1.) Develop prototype for new sensors to address sensor needs. 2.) Laboratory test and evaluation of new sensors under extreme low temperature environmental conditions. 3.) Field application of sensor system at DoD related site.

Potential Commercial Market: Contaminated sites at DoD and civilian sites are in the process of being identified. The number of sites is consistently growing due to increased effort and improved ability to locate sites. A recent trend is towards gaining a better understanding of the effects of imposed treatments compared to the potential for self-treatment with minimal input. Both of these strategies require a better understanding of the in-situ, three-dimensional processes occurring in the soil.

TOPIC: A94-092TITLE:Advanced Analytical Techniques for Determining Metal Speciation in Contaminated Soils
Point of Contact: WES

CATEGORY:

OBJECTIVE: To develop the hardware and computer software for an analytical method to measure and determine the quantity and metal species found in contaminated soils. The instrumentation should have the ability to determine the metal speciation of solid soil samples resulting in contamination down to concentrations of 1ppm, have graphic imaging capabilities, and have substantial resolution capabilities between different metals and species of these metals.

DESCRIPTION: Metal contaminated soils at military sites pose large contamination problems. Few treatment alternatives currently exist for the treatment of metal contaminated soils. For those technologies which do exist, there is a lack of understanding of effectiveness of such technologies both near- and long-term. One tool needed is the development of a solid phase soil analytical method for metals speciation. Several liquid extraction methods currently exist (commonly referred to as Sequential Extraction Methods) which attempt to identify metal species in soil. Unfortunately, problems have been identified which limit the usefulness of liquid extraction for the metal speciation in soils. Generally, species are loosely defined by the extraction procedures used to remove metal from the soils, and recent research indicates that the method itself results in substantial changes in the metal species. To overcome the shortcomings of the liquid extraction methods, other analytical techniques must be sought out. Such methods should be capable of not only identifying the quantity of metal in the soil without extraction (as is currently available with X-ray fluorescent techniques), but should also identify all species contaminating the soil at concentrations in excess of 1 ppm.

Phase I: Investigate new and innovative methods for identifying metal species in soils. Conduct limited bench scale testing to verify the feasibility of the most promising concepts. Design a prototype solid phase metal speciation

system based on the bench studies. Following a design review by the Army sponsor, finalize the conceptual design.

Phase II: Construct a prototype solid phase metal speciation system based on the approved conceptual design. After construction, the instrument should be thoroughly tested on known compounds and spiked soils. Detailed design drawings with specifications and a users manual should be provided to the Army sponsor. Army personnel should be trained to utilize and interpret the data.

Potential Commercial Market: This technology will have application in the chemical analytical industry as well as industrial and engineering firms currently involved with remediation activities. Development of solid phase metal speciation technology will provide information to assist in more effective environmental clean-up activities, thus providing protection to human health and welfare.

A-10ENGINEERING SCIENCES
(I.E. ROBOTICS, DYNAMICS, STRUCTURES, MECHANICS AND CONSTRUCTION)

TOPIC: A94-093TITLE:Alternative Engagement Technologies/Concepts Providing Low Collateral Damage/Less-Than-Lethal Dual Use Capabilities

Point of Contact: ARDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate alternative measures against a variety of threats and provide a low collateral damage/less than lethal dual-use capability, eg., law enforcement type application.

DESCRIPTION: There is a need to develop non-lethal techniques and mechanisms to disrupt both human and materiel system capabilities. It will involve the combination of strategy, tactics, weapons and other devices to: conduct non-lethal operations, provide an alternative to lethal force for deterrence during peacekeeping or conflict situations, augment lethal systems and protect friendly forces against such measures. Evolving technologies offer the potential for development of weapons that can disrupt or destroy an enemy's capability without causing lethal injury, excessive property damage or widespread environmental damage. Such concepts are not new to military operations but studies indicate that greater availability of such devices can provide an added dimension/flexibility to military operations. Required capabilities include but are not limited to the following:

a. Targeting: Use of disruptive tactics will require intensive intelligence support. Information on special vulnerabilities beyond accurate location and type of structure or system will be required.

b. Lethal versus Non-lethal Effects: New measurement techniques will be required to assess the effectiveness of non-lethal weapons. This includes test methods, bio-effects, simulation/models and battlefield effectiveness. Battlefield simulation models and verification test targets will need to be broadened to account for low collateral damage, non-lethality and psychological effects.

c. Operational Capabilities - desired features:

1. Reliability
2. Logistics - minimum loss of stowed load lethality
3. Deployable - from existing weapon system
4. Peacekeeping/Contingency - dual use

d. Tactical Capabilities - desired features:

1. Tunability - lethal to non-lethal
2. Kill assurance/assessment
3. Countermeasure - non-susceptibility
4. Deployable - from existing weapon system

Phase I: Develop methodology for design, implementation and evaluation of mechanisms for applications with multi-target capability being preferred. Versatility is desirable as is the capability to select on the battlefield the desired defeat level. For malate and demonstrate concepts for specific devices including preliminary operational scenarios. Good potential for Phase II should exist. Initiate development of marketing plans for Phase III efforts and identify user interest and potential dual-use applications.

Phase II: Develop laboratory prototypes and conduct tests to evaluate performance against various threat options. Evaluate impact using war game models and simulated targets. Develop preliminary plans for applications with suitable delivery vehicles and weaponization. Complete plans for Phase III and identify sources of funding.

Potential Commercial Market: Potential for Phase III should be high. It is anticipated that there will be a large military market for some of these devices and also a large potential market with law enforcement agencies.

OSCR: These low collateral damage weapons/devices may have logistical advantages over existing weapon systems. For example, they could aid in the reduction of training costs because low collateral damage would perm it training at smaller bases. There would be reduced costs for transporting equipment and soldiers, test personnel, etc to a larger base.

TOPIC: A94-094TITLE:Intelligent Sensor Based Robotic Control System Technology
Point of Contact: ARDEC

CATEGORY: Engineering Development

OBJECTIVE: Develop a generic multi-adaptive robotic control module and development environment for mobile manipulator systems for ammunition handling, resupply and logistics applications.

DESCRIPTION: Significant progress has been made recently in developing advanced sensor based servo control systems for high performance robotic manipulators. Specifically, a high speed 386 based multi-processor robotic control module and software development environment was developed which permits a broad range of adaptive and compliant motion control strategies to be implemented for arbitrary manipulator configurations. Extensions of this technology are required, however, to deal with fundamental problems o f mobility and base motion effect, flexible task level control, multi-sensor integration, dual arm coordination associated with fusing ammunition in a moving resupply vehicle, and depalletizing and transferring ammunition to and from resupply vehicle and loading ammunition in a moving platform environment. Technical issues of interest include robust and adaptive controls, compliant motion control, visual servo control, voice natural language interface for control, dual arm control strategies, world modeling design environment, real time, knowledge based task level control and control from moving base including path planning, navigation and obstacle detection/avoidance and component based software architectures.

Phase I: Develop methodology and algorithmic approaches to intelligent sensor based robotic control systems for applications to materiel handling and loading. Perform preliminary modeling and simulation studies to determine performance/robustness characteristics of the control laws and algorithms, real time processing requirements and sensor requirements. Provide analysis for evaluating control laws and provide control processor design and system hardware specifications.

Phase II: Develop controller hardware/software and development environment for interface with laboratory test bed manipulator systems. Develop test scenarios and scaled down mock-ups to demonstrate controller performance capabilities. Provide fully integrated prototype module with documentation source code and development environment and evaluate in laboratory tests.

Potential Commercial Market: The technology developed under this program can be utilized on any production line performing product handling, part mating and product transferring applications. Particularly, for the Army, this technology can be used in pro grams like Future Armored Resupply Vehicle (FARV-A) and Advanced

Field Artillery System (AFAS) to perform ammunition fusing, handling and loading during re-supply operations.

OSCR: This technology will provide cost reductions to Army operations where elimination of operators is needed. For instance, in programs like FARV-A and AFAS, this technology will be beneficial due to its potential application to operations such as fusing, de-pelletizing and transferring of ammunition to and from re-supply vehicle.

TOPIC: A94-095TITLE:Advanced Adaptive Weapon Control Technology
Point of Contact: ARDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate low cost high performance digital servo control technology for precision fire-on-the-move applications including armor, air defense and aircraft system applications.

DESCRIPTION: Recently progress has been made in demonstrating major accuracy improvements for both aircraft and combat vehicle weapon systems using advanced digital control design techniques and LOG LTR design approaches. Further improvements in gun accuracy are anticipated through the development of improved robust nonlinear and adaptive control laws and control laws that exploit recent advances in H infinity and 11 technology permits these techniques to be implemented in high bandwidth digital servo loops required for precision gun stabilization. This project will address the broad spectrum of issues associated with the development of design tools and methodology, modeling, simulation and real time hardware/software implementation.

Phase I: Develop methodology for design and implementation of high performance robust adaptive and nonlinear control laws for precision weapon stabilization and tracking. Formulate specific control laws for nominal two input, multi output nonlinear plan t with friction, backlash, resonant modes, high impulse periodic disturbances nonlinear compliance and sensor noise. Determine performance and robustness characteristics with respect to structural and unstructured plant perturbations and provide analysis of hardware/software implementation requirements.

Phase II: Develop a fully integrated design, test and prototyping environment for advanced nonlinear and adaptive multivariable control systems. Provide a real time programmable digital control module with on-line data analysis capability and I/O capability necessary for laboratory test bed evaluation. Optimize module hardware/software and algorithm design based on test data and provide complete documentation of algorithms and hardware/software architecture.

Potential Commercial Market: This work has a very high probability of being commercialized. The methodology and design environment developed in this SBIR can be used by many industries such as hydraulic and electric motor manufactures, machine tool manufactures, process control companies, automobile and aircraft companies, robotic applications, stabilized optical sight systems, etc. Anyone who designs control systems must confront nonlinearities, parameter variations, backlash, friction and resonant modes.

OSCR: Microprocessor-based control is a low-cost independent way to implement advanced control algorithms. One of it's biggest benefits is the ability to rapidly modify the control algorithms, making it very cost effective when upgrading a weapon platform or even moving the entire system to a new applications. Nearly all of the current controllers in the Army are analog based; i.e. capacitors, op amps and resistors fixed to a circuit card. Changes are very hard to make and portability between weapon platforms is impossible. If one microprocessor could be used for each servo control application in the Army with only the code being modified, the cost savings could be large. Another cost saving aspect of this work is the ability to get very high performance out of systems with backlash, friction, resonant modes, etc. What this means is that the Army can use a low-cost microprocessor-based Adaptive-Nonlinear Controller rather than buying new, very precise (and expensive) mechanical hardware or retrofitting existing systems to eliminate the nonlinearities, i.e. improve the performance with better algorithms and software rather than hardware.

TOPIC: A94-096TITLE:Navigation Issues for Low Cost Competent Munitions
Point of Contact: WTD

CATEGORY:

OBJECTIVE: The objective is to develop novel navigation and inertial measurement concepts for LCCM.

DESCRIPTION: The development of Low Cost Competent Munitions (LCCM) presents a number of technology challenges. The ability of the munition to "know" its position and velocity in an inertial coordinate system is critical. The munitions may be spinning at high rates (200 RPS) or rolling at slow rates (0 to 35 RPS). The effectiveness of artillery is measured by the dispersion about the target. LCCM offers to reduce (not eliminate) the dispersion. Many of the applications will be for gun-launched projectiles where the launch environment will be harsh (potentially 20,000'g or more). Concepts must have promise for small, rugged, and low cost solutions.

Phase I: Analysis and evaluation of novel navigation concepts for LCCM. Develop and refine the plan for Phase II.

Phase II: Design and fabricate hardware for a feasibility demonstration.

Phase III: Provide hardware and technological expertise for a LCCM feasibility demonstration.

Potential Commercial Market: The market potential for a low cost IMU is small but significant. Typical applications are stabilizing optics in cameras, camcoders and binoculars; navigation of robots; and small boat navigation.

TOPIC: A94-097TITLE:Computational Modelling Systems for Aerodynamic Design and Evaluation of Rotorcraft Concepts
Point of Contact: AVRDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate new and innovative computational methods that will enable reliable advanced aerodynamic design and evaluation of rotorcraft configurations by engineering personnel. The required methods must predict the performance, aerodynamic loading and acoustic properties of rotorcraft. Concepts developed must be suitable for use in the design environment and provide a common analysis medium for industry and Army conceptual analysis and evaluation teams.

DESCRIPTION: The Army rotorcraft fleet has experienced steady growth in operational needs concerning payload, range and performance - culminating in the need to study extensive fleet upgrades or even new aircraft. Such studies require analysis methods with the ability to perform rapid aerodynamic computations whose reliability will minimize or obviate the need for costly and lengthy testing and permit the expeditious evaluation of competing alternatives. This solicitation is for such an analysis system that can integrate a sufficiently wide variety of flows, provide the analyst with options to vary the required fidelity of the model and be fast enough for practical engineering usage.

The required analyses must encompass all the elements of flow physics required to predict rotor performance, loading and acoustic behavior. These flow elements include high-speed or high-lift induced transonic flows; inflow or transonic-induced unsteadiness; wake formation, convection and interaction; steady and unsteady separation effects: accurate drag prediction; components interference effects. It is understood that some flow effects - especially stall - may require the use of empirical models. However, the analysis must be based on a core solver that predicts the essential establishment and convection of the rotor wake both in the near-blade compressible flow field and in the distant wake.

This basic rotor/wake inviscid solver must be coupled to ancillary solvers that provide viscous corrections for prediction of profile power and stall onset. It is permissible to use semi-empirical models for post-stall behavior, however full stall-flow solvers of unusual promise are desirable. A more important feature is the ability to couple the flow to trim and blade deformation solver for the high-fidelity prediction of rotor behavior. In summary, a fast and accurate set of CFD analyses - integrated with a set of versatile surface and outer boundary conditions - are required that provide a wide and readily accessible range of analysis options to an engineering user. An essential feature of the analysis tool is that it be possible to run the basic flow solver on engineering work stations in order that widely separated Army analysts can perform the same or complementary computations. The analysis must be completely portable. It is also required that it be possible to "turn on" advanced levels of modelling as they are required - beginning with the inviscid rotor/wake behavior of a rotor with specified motion and working up in stages to a viscous rotor solution with a completely unconstrained blade motion.

Phase I: Investigate, identify and implement new and innovative solution methods for the fast prediction of rotor-wake flows and/or innovative means for the integration of all the necessary flow effects required to constitute a working model of a rotor. Demonstrate a basic flow method (a highly efficient model of inviscid, transonic, rotor-wake behavior) and a means to incrementally add increasing levels of physical fidelity as these are required for the prediction of critically important problems. Demonstrate that the basic model is compatible with practical work-station application and that the model is easily portable to larger machines as the physical fidelity of the solution grows. The model shall be shown to predict the performance of rotors in hover and the loading of rotors in forward flight. It should be demonstrated that the basic method has the ability to readily predict rotor-wake interaction effects and include the results of these in an acoustic analysis. The ability to couple the effects of blade motion and deformation shall also be demonstrated.

Phase II: Implement the full capabilities implied in the phase I demonstrations. Implement an accurate inner Navier-Stokes solver and test for ability to predict profile power and stall onset with accuracy. Couple the full blade wake-solution to a suitable trim and structural deformation code and demonstrate convergence. Implement a stall model. Couple a linear acoustic model. Construct a complete computational model for one or more Army rotorcraft requiring major upgrade studies.

Phase III: Prepare training documentation. Deliver the model to industrial design/engineering and Army engineering and evaluation personnel. Demonstrate the users ability to predict critical rotorcraft characteristics - such as hover performance or BVI noise - and to perform computational parametric studies of rotorcraft geometry on these and transfer the analyses and results to remote co-users. Demonstrate application of the code as a medium of technical exchange between remote users.

Potential Commercial Market: This technology will have application to the general prediction of all aviation problems wherein the aircraft is influenced by wake behavior. This will be especially important to the rotorcraft analysis and operations study market and an essential support to U.S. helicopter industry, which increasingly relies on outside sources for it's basic analysis methods.

TOPIC: A94-098TITLE:Application of Acoustic Sensors for Helicopter Health Monitoring
Point of Contact: AVRDEC

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate health monitoring of rotorcraft mechanical components using acoustic sensors.

DESCRIPTION: Monitoring of helicopter mechanical components using vibration has been successful and is well documented. Using high frequency acoustical methods may hold promise and ease problems with system implementation or retrofit on existing airframes. Acoustical methods need to be evaluated for application to on-aircraft real time monitoring. Under this program the ability to extract the necessary signals from the general background noise

and make accurate assessment of component health would be demonstrated. Data generated should not require post flight processing or analysis. Processing requirements, location effects and implementation issues would be addressed.

Phase I: A system for onboard monitoring of an aircraft critical component or components shall be designed. Various acoustical techniques shall be evaluated for the proposed application. Failure modes and signatures of the component will be defined and the effectiveness of acoustical detection techniques estimated. Detection levels as well as the time remaining until failure will be considered. Requirements for size, weight, and ruggedization for both sensor and processing units shall be addressed.

Phase II: The system designed in Phase I shall be prototyped and bench tested. This phase will fabricate and assemble the hardware necessary for testing. Multiple acoustical monitoring techniques shall be programmed for evaluation. Testing of the system will be conducted using an appropriate test stand or rig using seeded faults. Effectiveness of the various techniques will be determined.

Phase III: Design and qualify a production system suitable for application to both military and civil aircraft industries. This could take the form of a stand alone system or a sensor and analysis technique to be inserted in a integrated aircraft condition monitoring package.

Potential Commercial Market: This technology would have application to commercial aircraft. Techniques could be applied to any similar high cost mechanical system.

TOPIC: A94-099TITLE:Compact Infrared Zoom Lens Design
Point of Contact: MICOM

CATEGORY: Engineering Development

OBJECTIVE: To design and build a compact infrared zoom lens with size, weight, and volume constraints suitable for use in guided munitions.

DESCRIPTION: Guided munitions technology has progressed to the point of a need having been developed for compact and lightweight infrared zoom lenses. Typically, missile seekers use a wide field of view during the target search and acquisition phase, then switch to a narrow field of view for terminal homing. The sudden change of aspect within the field of view of the seeker when the switch is made from wide to narrow creates electronic and logic design complexities within the seeker design and a momentary adjustment period if a human is in the loop. A zoom lens would eliminate the problems associated with the sudden change in the seeker field of view. Typical infrared zoom lens designs are large and complex and usually offer a limited range of magnification ratios, and are not suitable for guided munitions applications; a compact and lightweight design would be suitable.

Phase I: Design an infrared zoom lens with dimensions less than 150 millimeters by less than 75 millimeters that operates in the 3-5 micron band, with a zoom range of 4:1, focal lengths from approximately 50-200 millimeters with constant f/4.5 and a field of view of approximately 5 degrees to 20 degrees. If necessary, this will include a survey of the manufacturing methods available for production. An optical and thermal analysis of the design will be conducted along with a manufacturing tolerance evaluation.

Phase II: Manufacture an infrared zoom lens based on the design provided in Phase I using suitable infrared materials. Design, manufacture and test the mechanical mounts and motion control hardware for the lens, align the zoom lens system and evaluate it s optical performance at selected points that span the full field of view and range of zoom.

Potential Commercial Market: A compact infrared zoom lens has potential use in any commercial market associated with infrared sensing such as surveillance and remote sensing when size and weight restrictions are necessary or cost effective.

TOPIC: A94-100TITLE:In Bore Projectile Speed Measurement System for Use in Electromagnetic Launchers
Point of Contact: TECOM

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate a system capable of measuring projectile speed continuously from first motion until muzzle exit inside of electromagnetic launchers during gun testing. Concepts developed must work in harsh environments of high electro magnetic noise, plasma gas and mechanical shock and vibration, and be able to recover the signal in the event of transient data dropouts.

DESCRIPTION: Electromagnetic launchers, varying in length up to 10 meters long, and with round and square bores up to 90 millimeters are being developed and tested throughout the world, and on a tri-Service level in the United States. A considerable effort is being made to develop projectiles for these guns. Current in-bore projectile speed measurements are made using B-dot probes placed discretely along the guns. The data are prone to noise induced by the harsh electromagnetic environment, and the spacing between the sensors is very large considering the projectile speed of 5 km/sec and rapid acceleration. A system based on a doppler laser, that is immune to the electromagnetic noise, and capable of performing the desired measurements is desired. The laser system must be able to recover the signal in the event of dropout due to transient bursts of plasma gas leakage past the projectile. The speed information must be updated on the microsecond level, and speed measurement must be accurate to within 10 meters/sec at maximum projectile speed to assure good data. Smooth projectile speed information, updated often and with high accuracy, can be used to calculate projectile position and acceleration in the gun, which could be used to estimate the forces on the projectile.

Phase I: Investigate new and innovative ways to capture, process, save and analyze in-bore projectile speed measurements. The investigator will obtain all currently available information pertinent to this task and determine how to solve the many technical problems associated with solving the speed measurement problem. Phase I should demonstrate that the concept will be able to recover the signal in the event of dropouts due to transient signal loss, and that the system will work in an existing electromagnetic launcher without signal degradation due to the insulators between the rails of the gun and the high electromagnetic noise in and around the gun during testing. The investigator should also demonstrate that the system can update speed information every 30 microseconds and be accurate to within 10 meters/sec when projectile speed is from 0 to 5 km/sec.

Phase II: Implement the new concepts into a working system that is easy to filed and align, withstands the shock and vibration of conventional and electromagnetic guns, and is portable and reliable.

Potential Commercial Market: The technology required to develop a fielded system is applicable to various gun manufacturers such as the makers of small arms. The technology required to process laser doppler information quickly enough to solve this problem has application in advanced spread spectrum communications systems such as digital cellular telephones. Frequency hopping cellular phones require very sophisticated diagnostic tools which are currently not available. Law enforcement agencies need this capability to monitor frequency hopping cellular phone conversations.