U.S. ARMY 95.3
SUBMISSION OF PROPOSALS

Topics

The Army participates in one solicitation each year with a coordinated Phase I and Phase II proposal evaluation and selection process. The Army has identified 126 technical topics for this solicitation which address the Technology Areas in the Defense Technology Plan and the Army Science and Technology Master Plan. The commercial potential for each of these topics has also been identified.

Technology Areas

Below is a listing of the Science and Technology Areas. Descriptions of these areas are provided on the following pages.

1 Aerospace Propulsion and Power
2a Air Vehicles
2b Space Vehicles
3 Battlespace Environments
4 Biomedical
5 Chemical and Biological Defense
6 Clothing, Textiles, and Food
7 Command, Control, and Communications (C3)
8 Computing and Software
9 Conventional Weapons
10 Electronics
11a Electronic Warfare
11b Directed Energy Weapons
12a Environmental Quality
12b Civil Engineering
13 Human Systems Interface
14 Manpower, Personnel, and Training
15 Materials, Processes, and Structures
16 Sensors
17a Surface/Under Surface Vehicles-Ships and Watercraft
17b Ground Vehicles
18 Manufacturing Science & Technology (MS&T)
19 Modeling and Simulation (M&S)

Proposal Guidelines

The maximum dollar amount for Army Phase I awards is $70,000 and for Phase II awards is $600,000. Selection of Phase I proposals will be based upon technical merit; evaluation procedures and criteria are discussed in this solicitation document. Due to limited funding, the Army reserves the right to limit awards under any topic and only those proposals considered to be of superior quality will be funded. To reduce the funding gap between Phase I and Phase II, the Army follows a disciplined milestone process for soliciting, evaluating, and awarding superior Phase II proposals. Phase II proposals are invited by the Army from past and ongoing Phase I projects which have demonstrated the potential for commercialization of useful products and services. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing developed technology. Cost sharing arrangements in support of Phase II projects and any future commercialization efforts are strongly encouraged. Commercialization plans and cost sharing provisions will be considered in the evaluation and selection process. Phase II proposers are required to submit a budget for a base year (first 12 month) and an option year. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

Proposals not conforming to the terms of this solicitation and unsolicited proposals will not be considered.

Key Dates

July 7, 1995 Solicitation 95.3 Closes (Deadline for Phase I proposal submission)
September 30, 1995 Deadline for Phase II proposal submission to Army (from past and ongoing Phase I projects)
Please Note: All Phase II proposals received after 30 September will not be considered
December 8, 1995 Phase I and Phase II Proposals Selected for Award
January 15, 1996 Phase I and Phase II Notification of Awards
January/February 1996 Phase I and Pahase II Contracts Executed

Recommendation of Future Topics

Small Businesses are encouraged to suggest ideas which may be included in future Army SBIR solicitations. These suggestions should be directed at specific Army research and development organizations.

Inquiries

Inquiries of a general nature should be addressed to:

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Alexandria, VA 22333-0001
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DESCRIPTIONS OF THE TECHNOLOGY AREAS

Area 1: Aerospace Propulsion and Power

The Aerospace Propulsion and Power technology area includes those efforts directed toward propulsion and power systems for aircraft, missiles, and space vehicles. There are four major sub-areas: Integrated High Performance Turbine Engine Technology (IHPTET), focused on gas-turbine propulsion systems for aircraft and cruise missiles; Integrated High Payoff Rocket Propulsion Technology (IHPRPT), focused on propulsion systems for space and missile systems; high-speed propulsion and fuels, focused on ramjet, scramjet, combined-cycle propulsion systems for missiles and space-launch systems, and fuels; and aerospace power, focused on non-propulsive power generation systems for aircraft, missiles, and space vehicles.

Area 2: Air Vehicles

The Air Vehicles Area, which provides affordable, global delivery of people, supplies, weapons and sensors, is divided into fixed wing vehicles, rotary wing vehicles, unmanned air vehicles and system integration technology. Technology efforts are aeromechanics, flight controls, subsystem, air vehicle structures.

Area 2b: Space Vehicles

The technologies assembled under the Space Technology Area are those oriented toward the spacecraft bus, as opposed to payload; technologies unique to space and the military; and their implementation thru flight experiments. The Space Technology Area has eight sub-areas: propulsion, focused power, thermal management, advanced materials, survivability, navigation, integration, and flight experiments.

Area 3: Battlespace Environments

The Battlespace Environments technology area encompasses the study, characterization, prediction, modeling, and simulation of the terrestrial, ocean, lower atmosphere, and space/upper atmosphere environments to understand their impact on personnel, platforms, sensors, and systems; enable the development of tactics and doctrine to exploit that understanding; and optimize the design of new systems.

Area 4: Biomedical

Biomedical S&T (BST) programs are focused to yield superior technology in support of the DoD mission to provide health support to U.S. military forces. Defense BST programs are aligned to the following seven functional areas: infectious disease of military importance, combat casualty care medical biological defense, medical chemical defense, military operational medicine, military dentistry, and ionizing radiation bioeffects.

Area 5: Chemical and Biological Defense

The purpose of Chemical and Biological Defense research is to develop equipment that will protect our forces, sustain combat operations, and maintain system effectiveness in a chemical and biological contaminated environment. The chemical and biological defense technology area includes four major subareas: detection, protection, decontamination, and information processing and dissemination.

Area 6: *Clothing, Textiles, and Food*

The DoD Clothing, Textiles, and Food technology area focuses on protecting and sustaining soldiers, sailors, airmen and marines, individually and collectively. This technology area is comprised of two sub-areas: clothing and textiles, and food. The clothing and textiles sub-area includes all textile-related polymer, fiber, yarn, fabric, film, dye, pigment, coating, textile based technologies, and clothing systems, as well as the products' packaging which should enhance survivability, performance, and mobility. The food sub-area includes nutritional performance enhancement, food preservation, food packing, consumer acceptance, and equipment and energy technologies.

Area 7: *Command, Control, and Communications (C3)*

This science and technology area encompasses Command, Control, and Communications systems of all types: data processing hardware and software dedicated to operational planning, monitoring or assessment (including information fusion), distributed processing, distributed data storage, and distributed data management.

Area 8: *Computing and Software*

The Computing and Software Technology Area enables the creation of a broad range of advanced information processing systems of critical value in support of the missions of the Department of Defense (DoD). The Computing and Software area can be broadly grouped into six major subareas: system software, software and systems development, intelligent systems, user interface, computing systems and architecture, and networking.

Area 9: *Conventional Weapons*

The Conventional Weapons Area develops conventional armaments technologies for all new and upgraded non-nuclear weapons. It includes efforts directed specifically toward non-nuclear munitions, their components and launching systems, guns, bombs, guided missiles, projectiles, special warfare munitions, EOD devices, mortars, mines, countermine systems, torpedoes, and underwater weapons along with their associated combat control. There are six major sub-areas: fuzing/safe and arm; guidance and control; guns; countermine/mines; warheads and explosives; and weapon lethality/vulnerability.

Area 10: *Electronics*

The Electronics Technology Area extends from basic research to applications at the subsystem level. Electronics includes the research, development, design, fabrication, and testing of electronic materials; electronic devices, including digital, analog, microwave, optoelectronic, vacuum and integrated circuits; and electronic modules, assemblies, and subsystems. The Electronics Technology Area is organized into five major sub-areas: RF components, electro-optics, microelectronics, electronic materials, and electronic models and subsystems.

Area 11a: *Electronic Warfare*

The Science and Technology Program in the Electronic Warfare (EW) area develops technology for the offensive and defensive application of EW. It includes efforts to intercept, counter, and exploit the complex threat weapons spanning the entire electromagnetic spectrum, including radio frequency (RF), infrared (IR), electro-optic (EO), ultraviolet (UV) and multispectral/multimode sensors. These technologies are applied within three subareas: force protection, offensive EW, and EW support functions.

Area 11b: Directed Energy Weapons

Directed Energy Weapon (DEW) technologies are those that relate to the production and projection of a beam of concentrated electromagnetic energy or atomic/subatomic particles. Directed energy (DE) weapons and devices generate energy that travels at or near the speed of light from a beam source directly to the target. The DEW Technology Area is divided into three sub-areas: laser weapons, RF weapons, particle beam weapons, or charged atomic or sub-atomic.

Area 12a: Environmental Quality

The Environmental Quality technology area provides technologies to reduce the costs of DoD operations while ensuring mission accomplishment is not jeopardized by adverse environmental impacts. There are four sub-areas: cleanup of contaminated sites, compliance with all laws, prevention of pollution, and conservation.

Area 12b: Civil Engineering

The Civil Engineering Technology Area efforts solve critical DoD civil engineering problems related to training, mobilizing, deploying, and employing a force at any location at any time. This technology area includes survivability and protective structures, airfields and pavements, conventional facilities, critical airbase facilities and recovery, ocean and waterfront facilities and operations, sustainment engineering, and fire fighting.

Area 13: Human Systems Interface

Human Systems Interface (HSI) technology fully leverages and extends the capabilities of warfighters and maintainers to ensure that fielded systems will exploit the fullest potential of the warfighting team, irrespective of gender, mission or environment. It is organized into four areas: crew systems integration and protection, performance aiding, information management and display, and performance assessment and design methodologies.

Area 14: Manpower, Personnel, and Training

The Defense Manpower, Personnel, and Training science and technology program seeks to maximize human military performance. Manpower and personnel addresses the recruitment, selection, classification, and assignment of people to military jobs by seeking to reduce the attrition of high-quality personnel and helping the senior department leadership to predict and measure the consequences of policy decisions. Training systems technology improves the effectiveness of the instruction, the efficiency of student flow through the training pipeline, military training systems, and provides opportunities for skill practice and mission rehearsal, for a lower life-cycle cost.

Area 15: Materials, Processes, and Structures

Materials, Processes, and Structure (MP&S) technologies produce an enabling array of capabilities for every DoD system that flies, navigates, and fires or is fired upon. MP&S technologies are equally critical in maintaining the DoD infrastructure, from military piers and trucks to sophisticated sensors and optical systems, and in reducing the impact of defense systems on the environment. MP&S spans all material categories--metal and intermetallic alloys; ceramics; polymers; composites of all types; semiconductors; superconductors; optical, ferroelectronic, and magnetic materials; and materials for power sources.

Area 16: Sensors

The Sensors technology area develops technologies in five major subareas: radar sensors, electro-optic sensors, acoustic sensors, automatic target recognition, and integrated platform electronics and sensors. Applications include strategic and tactical surveillance, identification and targeting of threats from all military platforms including satellites, aircraft, helicopters, ships, submarines, ground vehicles and sites, unmanned air vehicles, unattended ground sensors and the individual soldier.

Area 17a: Surface/Under Surface Vehicles-Ships and Watercraft

The Ships and Watercraft Technology Area provides the technology for improved combat efficiency, survivability, and stealth of surface ships, submarines and unmanned undersea vehicles.

Area 17b: Ground Vehicles

The Ground Vehicles Technology Area incorporates technologies to support the basic Army and Marine Corps land combat functions: shoot, move, communicate, survive and sustain. Covered here are propulsion and power, track and suspension, vehicle subsystems, hydrodynamics, signature reduction, fuels and lubricants and integration technologies related to land combat vehicles, including amphibious vehicles with a ground combat role.

Area 18: Manufacturing Science & Technology (MS&T)

The Manufacturing Science and Technology area is focused on cross-cutting engineering and manufacturing process technologies beyond those developed in conjunction with new product technologies in the other technology areas: advanced technology demonstrations for affordability, and advanced industrial practices to demonstrate the combination of improved process technology and improved business practices, programs encompass technologies at all manufacturing levels (enterprise/factory/cell/machine/unit process).

Area 19: Modeling and Simulation (M&S)

The Modeling and Simulation technology area includes development, integration, and implementation of tools and applications to apply M&S with greater validity across DoD. Efforts are directly dependent on enabling technologies such as high speed computing, communications and networking, human systems technologies such as high speed computing, communications and networking, human systems interfaces, and software.

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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ARMY SBIR PROGRAM
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COE/WES	P. Stewart	(601) 634-4113	A95-109/A95-110

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DEPARTMENT OF THE ARMY
FY 1995 TOPIC DESCRIPTIONS

A95-001TITLE:Automated Compression Forming for Continuous Fiber Reinforced Composite Structure

CATEGORY: Exploratory Development

OBJECTIVE: To foster the development of an integrated fabrication process consisting of an advanced weaving technology to produce net-shaped tailored fabric, an automated compression forming process and a non-autoclave curing process using electro-beam radiation. An integrated fabrication process will facilitate the creation of complex structural parts without sacrificing structural performance while minimizing labor, tooling and material cost. Such a process will greatly reduce the high fabrication costs currently associated with composite structures.

DESCRIPTION: The broad application of continuous fiber reinforced structures has been severely restricted due to the high fabrication cost associated with these materials. Multiple rolls of net-shape fabric can be assembled to form a structural preform using a compression forming process similar to that used in a metal stamping process. During the compression forming process the resin is injected into the fabric preform and after full wet out of the preform the resin solidifies. An alternative approach to resin injection is the use of resin powder coating on the structural fibers prior to weaving the fabric. Once the resin has solidified, but is uncured, the structural part is cured using electron-beam radiation. Electron-beam curing eliminates the necessity of tooling and bagging of the structure during the cure process.

PHASE I: Develop a process for forming a multi-layer composite structural part consistent with the aforementioned fabrication process. The forming process may be a multi-step process consisting of a partial debulking step followed by a final debulking and resin injection/melting and solidification step. The individual elements of this process shall be demonstrated without attempting to fully automate the process; however, the processes must be fully integrateable.

PHASE II: Integrate the separate fabrication steps into an automated process minimizing the total fabrication costs associated with the process. Demonstrate the fabrication process by fabricating multiple complex structural elements. Fabrication cost analysis shall be performed using this technology. The structural part shall be electron-beam cured and undergo destructive evaluation to assess its structural performance.

POTENTIAL COMMERCIAL MARKET: An integrated fabrication process which minimizes labor, and the use of autoclaves, while reducing tooling and material cost will greatly reduce the current high composite fabrication cost. Once developed new markets for these materials will rapidly evolve.

A95-002TITLE:Non-Destructive Evaluation Technology for Determining Bonding Integrity for Joining Materials at Micro-Level

CATEGORY: Exploratory Development

OBJECTIVE: The principal objective of this effort is to develop and demonstrate a non-contact technology for determining bonding integrity of materials at the micro-level. This sensor must be fast enough to support high speed manufacturing processes used in its field. Example applications include diamond coating, delamination of thick or thin film traces, lid sealing of microcircuit packages etc.

DESCRIPTION: The long-term trend in microelectronic, semiconductor and electronic industries is smaller, denser, and faster with each generation and is approaching some serious defect levels. One of the obstacles in reducing the defect level is the inability to detect micro flaws on materials, at high speed and resolution, during its manufacturing process. Due to the fragility of its structure and crucial positioning of its interconnects, traditional contact sensors are losing their effectiveness in terms of speed and dexterity. Mechanical pull/shear, machine vision and X-rays are

ineffective technologies for our applications. A high speed and high resolution sensor for determining the presence, absence and degree of attachment of micro-joints will be developed under this effort.

PHASE I: Requires research and development of an innovative concept using relevant sensor technologies for determining micro-bonding integrity at high speed and resolution. This concept must be technologically feasible and meet the objectives of reducing quality control costs, manufacturing bottle necks, and be suitable for automated process control.

PHASE II: Prototype of the proposed sensor in Phase I will be designed and built based on results of the Phase I effort. Deliverable would include a complete design analysis, design documentation package, and a prototype station suitable for test and evaluation, using appropriate assemblies supplied by the Army. The contractor will participate in the evaluation tests to guarantee the system is working at full capability and provide timely modification as needed to optimize system performance.

POTENTIAL COMMERCIAL MARKET: New knowledge and technology advances resulting from this development will enable us to monitor and explore material behaviors before, during and after its manufacturing or assembly processes. It will provide a stepping stone for much broader applications in the field of material processing. Industries that can use this sensor technology for process control improvements and controls include military, aerospace, commercial electronics, microelectronics, metal working, composites, printed circuit manufacturing, thick film & thin film circuits and plastics. Cost savings are realized by eliminating post-process inspection, reduce scrape, reduce rework, improve throughput time, and above all allow real-time process monitoring and control.

A95-003TITLE:Processing of Advanced Lightweight Metals, Ceramics and Composites Thereof

CATEGORY: Exploratory Development

OBJECTIVE: Develop technologies capable of enhancing the economic processing of advanced materials for lightweight vehicle applications.

DESCRIPTION: Innovative developments on advanced lightweight metals, ceramics and metal matrix composites processing technologies could be applied to fulfill significant current and future Army needs. Proposals are sought on such developments that address the Army needs and technology opportunities described in the following. Each proposal must be responsive to a single materials area with the Army as well as the commercial need/s clearly delineated. * Low cost titanium for ground vehicle applications * Functionally gradient ceramic-metal materials for armor * Powder injection molding of net-shape metal and ceramic components * Scalable process for production of low-cost, fine (less than 5 micrometers) powders of titanium diboride, silicon carbide, and boron carbide for armor ceramics * Reduction of hot-pressing densification temperatures of armor ceramics * Energetic (Laser/Ion) beam treatments and coatings for enhanced tribology and armor performance

PHASE I: Demonstrate the feasibility of applying innovative concepts to advanced lightweight materials on simple components and deliver samples to the Army for evaluation

PHASE II: Optimize, scale-up and validate the processing technology pursued in Phase I. Develop prototype equipment and demonstrate its capability to meet quality, production quantity and reproducibility goals by producing and delivering prototype components for Army evaluation, and assess industrial production costs.

POTENTIAL COMMERCIAL MARKET: The commercial potential of innovative developments that enhance processing of advanced lightweight metals extends into many industries. Applications in the areas of light vehicles will save enormous amounts of energy and natural resources without sacrificing safety and durability. Other applications include aircraft, engines and bearings.

A95-004TITLE:Dendrimer-Based Protective Coatings for DoD Materiel

CATEGORY: Exploratory Development

OBJECTIVE: Develop dendrimer-based protective coatings that are resistant to POL (petroleum, oil, and lubricant) degradation and chemical agent contamination, and scale up production to a commercial level.

DESCRIPTION: Dendritic polymers are a relatively new class of nanostructures that, unlike linear polymers, are prepared with precisely controlled properties such as size, shape, and surface reactivity. Because of the precisely controlled architecture, they can be thought of as molecular building blocks that can be designed to create molecular scale devices or that can be "assembled" to form mesoscale materials (nanometer to micron range). Although kilogram-scale production is reportedly in progress, few commercial applications have been precisely defined. This solicitation seeks research to develop dendrimer-based coatings that are mechanically tough with repellent or resistant properties of interest to DoD. A number of approaches are possible including using dendrimers as a component in a coating or material, tailoring dendrimer chemistry to attach dendrimers directly to surfaces, or chemically reacting dendrimers to form mesoscale or network materials. Of particular interest are coatings that are environmentally stalwart over time which repel or resist POLs and chemical agent contamination.

PHASE I: Develop dendrimer coatings that are environmentally robust and are resistant to POLs and chemical agent contamination.

PHASE II: Based on the results of Phase I, fine tune the repellent/resistant properties of the coatings for specific DoD applications in conjunction with the U.S. Army and test the coatings on DoD materiel. Scale up production to a commercial level.

POTENTIAL COMMERCIAL MARKET: Dendrimer coatings would protect DoD materiel such as vehicles and weaponry from chemical agent contamination and degradation due to POL and environmental exposure. For DoD and the civilian sector, the coatings would provide protection during environmental clean-up operations, and protect vehicles, aircraft, and other equipment from wear and degradation due to environmental and POL exposure. Dendrimer-based materials have diverse potential applications including as detection devices for chemical agents and environmental toxins, for catalytic detoxification of chemical agents and chemical waste, as lubricating, protecting, and barrier coatings, as adhesives, filters, membranes, reinforced polymer composites, insulating materials, as controlled release materials for drug delivery, agricultural applications, and stimulated lubrication, and for electronics and optical device applications.

A95-005TITLE:Supercritical Fluid Production of Polyphosphazene Materials

CATEGORY: Exploratory Development

OBJECTIVE: Develop a supercritical fluid synthesis of polyphosphazenes, characterize the process and products, and scale up the process for economical commercial production.

DESCRIPTION: Polyphosphazenes are a class of polymeric materials that have numerous potential uses including as high performance elastomers (rubbery materials), membranes, fire resistant materials, optical materials, and biomedical materials. The large number of diverse applications for this class of polymers is due to tailoring the material properties by substituting a variety of different substituents onto the polymer backbone. While research continues on the synthesis of new materials and variations to synthetic strategies, to date there are few polyphosphazene products commercially available due to the relatively high cost of production. This solicitation seeks the development of a supercritical fluid pathway for polyphosphazene synthesis. This methodology has yet to be applied to polyphosphazene production although success has been demonstrated for other polymers of commercial interest. It is expected that supercritical fluid synthesis can be a cost effective means for producing well defined polyphosphazene based materials of interest to DoD and the civilian sector. A supercritical fluid pathway will eliminate the relatively large quantity of waste products associated with polyphosphazene production.

PHASE I: Develop a supercritical fluid means to economically produce polyphosphazenes of interest to DoD and characterize the process and resultant materials.

PHASE II: Scale-up the approach developed in Phase I to produce polyphosphazene based materials with well-defined properties of interest to DoD, including solvent resistant materials, materials stable at high temperatures, materials which remain flexible at low temperatures, and flame resistant materials. Polyphosphazene-based components will be produced and tested in conjunction with the U.S. Army.

POTENTIAL COMMERCIAL MARKET: These materials have potential applications for DoD and the civilian sector as vehicle and equipment components including high performance materials, solvent and oil resistant materials, seals, gaskets, o-rings, and belts, as fire resistant materials for use on aircraft and on ships, as membranes for chemical protection, as biomedical materials, and as drug delivery systems.

A95-006TITLE:Application of Coatings to Advanced Materials

CATEGORY: Exploratory Development

OBJECTIVE: Develop affordable coatings to complement materials applicable to advanced gas turbine engines and thus, allow increased capability and optimum benefit of the material employed to be realized.

DESCRIPTION: A significant opportunity exists in the application of advanced materials to many components of industry/Government gas turbine engines. The use of advanced materials will enable significant increases in power-to-weight ratios and reductions in specific fuel consumption. For example, ceramic matrix composites (CMC) are being utilized for turbine shrouds and high temperature titanium aluminides, such as super alpha 2 and orthorhombic titanium aluminides, are being employed in the impeller. However, associated with the application of these advanced materials is the need for new coatings which, depending on the application/material, would allow increased capability of the component to be realized. As with the aforementioned examples, if a turbine shroud were fabricated with a CMC then a slight rub could cause fiber damage/breakage, thus an abradable coating would be desirable to allow for a slight shroud rub by the turbine blade and allow continued operation without performance/life degradation. The application of the advanced high temperature titanium aluminides in the impellers creates an oxidation problem at anticipated use temperatures and would necessitate a coating to prevent oxidation. Additionally, the high rotational speeds encountered in advanced engines increases the stresses due to centrifugal forces in roller bearings and greatly reduces the life of the bearings under typical loads. Application of a hydrodynamic deflection pad bearing is a potential solution to increase bearing life; however, a low friction coating must be developed for the pads. Therefore, the development of new coatings to compliment the application of advanced material applications has high payoff potential for both commercial/Government power generation.

PHASE I: Identify a component/material targeted for an advanced engine application. Assess the current capabilities, define operational requirements and identify the potential benefits which could be accrued through application of a new coating. Investigate several candidate coatings. The coatings must have characteristics consistent with those required in an advanced engine environment. Perform preliminary analysis, tailored to chosen coating/material/ component system, to determine viability of candidate coating systems. Down select to most promising coatings (two or three).

PHASE II: Define test techniques specifically designed to simulate the anticipated operational environment for the selected component/coating systems. Utilizing results of tests, down select to most promising coating. Develop a coating application process. Perform testing of a full scale coated component in a gas turbine rig and/or engine to substantiate benefits achievable.

Phase III: Focus on the commercialization of the coating technology demonstrated in Phase II.

POTENTIAL COMMERCIAL MARKET: The resulting technology will facilitate achievement of engine components having reduced weight, higher temperature capability, and/or increased durability. This technology will prove very beneficial to both the military and commercial sectors, being applicable to a wide variety of applications such as tank, automobile and aircraft primary power, heat exchangers, auxilary power units, etc. The resulting product has a large potential market with enormous cost savings potential.

A95-007TITLE:Robust Interfaces for Embedded Fiber Optic Devices

CATEGORY: Exploratory Development

OBJECTIVE: Develop, characterize, and demonstrate inexpensive, durable (robust) connectors or interfaces for optical fibers which are embedded in advanced aerospace structural materials such as thermoset or thermoplastic composites, metallic alloys and composites, and/or ceramic materials.

DESCRIPTION: Applications for optical fibers that are embedded in aerospace structures and engine components are being developed to the point that in-situ processing monitors, strain sensors, neural networks, etc., are technically feasible. A limiting factor in the development and deployment of embedded fiber optics is the fragility and expense of the fiber optic interface between the component in which the fiber is embedded and the sensing optical or transmitting LED/LASER device. The expense and durability/robustness of connections to tens or hundreds of fiber optic "leads" that may emanate from a single composite structure with an embedded neural network become driving design and practicality issues. It is envisioned that discontinuous optical interfaces (windows or lenses) that could be placed in intimate contact with cleaved or otherwise cleanly terminated fibers would allow optical transmission to occur. Another possibility could be the actual embedment of extremely small LED or LASER diodes and IR or other wavelength receptors within the structure or component, allowing for simple electrical interfaces to signal processing equipment and power sources. The solution to the fiber optic interface problem must be affordable, survivable in high vibration/temperature environments, and not overly constrictive to the design engineering process. Development of robust in-situ fiber optic interfaces will support S&T Thrust #7 Technology for Affordability, and Structural Integrity Program objectives.

PHASE I: An examination of the excitation and sensing light frequencies, amplitudes, and tolerable S/N ratios for various fiber optic applications (which are easily available in the literature) will be conducted to define the minimum transmission requirements for an embedded optical fiber interface. A conceptual design of the interface concept will be performed. A breadboard or prototype interface will be manufactured and tested for baseline performance for the applicable transmission requirement. The overall feasibility of the concept will be evaluated, and improvements/modifications for further development identified. Bi-monthly technical progress reports shall be submitted. A final technical (end of program) briefing shall be presented to the Army at the Aviation Applied Technology Directorate, USAATCOM, AVRDEC, Fort Eustis, Virginia.

PHASE II: The object of this phase will be to demonstrate significant design, manufacturing, and operational use benefits of the fiber optic interface concept compared to current fiber coupling methods. The developed interface concept's utility and robustness will be evaluated in a simulated or actual manufacturing scenario for one or more types of aerospace components or structures with embedded optical fibers. Specific metrics for evaluation shall include transmissivity, induced noise, durability, and cost. Elimination of any peculiar constraints, such as special care and handling of exposed fiber ends, imposed by the fibers in the manufacturing process will be emphasized.

POTENTIAL COMMERCIAL MARKET: Despite the considerable promise of fiber optics and sensors in composites and other structures or components, the actual implementation of embedded fibers has not been reduced to practice, in part due to the considerable fabrication issues involved with handling of the fiber optic "tails". Small, inexpensive, non-invasive interfaces for embedded optical fibers will eliminate one of the fundamental barriers to implementation of fiber optic sensors and networks in military and other high performance applications.

A95-008TITLE:Non-Eroding Fin Materials

CATEGORY: Exploratory Development

OBJECTIVE: Advanced missile control systems are currently using fin in plume technologies. Current fin materials erode during system operation making precise flight control difficult. A non-eroding fin material is sought which will provide no erosion or limited reproducible erosion of the fin aerodynamic surfaces.

DESCRIPTION: In order to solve this problem, both monolithic and multiple high temperature fin materials must be considered. Multiple material fins present material incompatibilities during processing and component service which

must be understood to provide a successful design. These multi-material configurations induce thermal stresses, and thus are susceptible to flaking and cracking during both processing and service life.

PHASE I: Phase I of this research effort should concentrate on analytical modeling of conceptual fins to define the magnitude of thermal stresses developed during service, residual stresses after processing, and methods of reducing these residual stresses. Multiple material fins should be considered, with composite materials being designed to minimize the residual thermal stresses.

PHASE II: The PHASE II effort should demonstrate the design concepts developed in PHASE I by fabricating and testing several fins. The analytical tools developed in PHASE I should be demonstrated to be capable of predicting the fin material stress states. Combined material and configuration optimization should also be demonstrated in the phase II effort.

POTENTIAL COMMERCIAL MARKET: Development of non-eroding multi-material systems have commercial potential in the turbine and piston engine industries. Other applications include high speed aircraft control surfaces.

A95-009TITLE:Fiber Optics in Filament Wound Structures

CATEGORY: Exploratory Development

OBJECTIVE: The objective of his task is to develop novel processing technology to incorporate optical fibers in a filament wound composite structure. The purpose of the fiber optics could be to determine displacement, strain or temperature.

DESCRIPTION: Fiber optics in composite structures could be used for a host of areas such as monitoring cure cycle, measuring displacement and strain, and monitoring service life of rocket motorcases. It is not known what the fiber optic can do to the structural integrity of a filament wound structure such as a pressure vessel or rocket motorcase. The positive aspects of fiber optics might be offset by the degradation of the structure. It is important to characterize the effects of an integrally filament wound fiber optic in a composite structure.

PHASE I: Phase I of this research task should concentrate on techniques to place fiber optics in filament wound composites. A series of simple test articles should be identified. Placement and location of the fiber optic should be analyzed for the effects of structural integrity on the test articles.

PHASE II: The simple series of tests identified in Phase I should be made and the results compared with analysis. More complex filament wound structures such as pressure vessels or a rocket motorcase should be manufactured with fiber optics at different locations and tested for structural effects.

POTENTIAL COMMERCIAL MARKET: This type of processing technology could be utilized in the commercial market where there is a need for information from a structure. Manufacturing of commercial composites could use fiber optics as a measure of a cure cycle. An excellent application would be monitoring of the strain of composite rocket motorcases for service life. Some other types of tankage would include swimming pool filters, air plane fuel storage tanks, fireman tankage and fuel containers.

A95-010TITLE:Development of New Materials for Small Arms Defeat

CATEGORY: Exploratory Development

OBJECTIVE: To develop new innovative materials for small arms protective body armor.

DESCRIPTION: Current body armor designed to protect against small arms threats typically consist of rigid materials with a reinforcement backing. The strike-face materials are usually metal or ceramics backed with fiber-reinforced composites. This topic specifically seeks to develop new innovative materials to provide protection against small arms threats. Successful materials will have a weight per unit surface area of 5.0 pounds per square foot or less, have a thickness of not more than one inch, and defeat all types of 7.62 ball ammunition at muzzle velocity and 0 degrees obliquity. Attention should also be given to affordable, large-scale production potential.

PHASE I: Identify and develop innovative materials with potential for meeting ballistic performance and weight requirements. Demonstrate potential to meet performance goals through laboratory scale testing.

PHASE II: Optimize selected Phase I candidate/s and demonstrate desired performance in a prototype model. Deliver prototype systems for government evaluation and verification for final acceptance. Provide final technical report with technical data package for optimized materials.

POTENTIAL COMMERCIAL MARKET: This technology will be directly transferable to the law enforcement body armor industry.

A95-011TITLE:Automatic Fiber Placement (AFP) Process for Polymer Composite Sabots

CATEGORY: Engineering Development

OBJECTIVE: Develop a manufacturing process for composite sabots utilizing Automatic Fiber Placement (AFP) technology.

DESCRIPTION: Current large caliber tank ammunition utilize sabots made from composite materials. The cost of these units is fairly high due to several factors: the initial costs of the prepreg material itself; the manufacturing process requires the cutting and handling of a multitude of small parts; the high scrap rate due to the "sheet stock" form of the prepreg material. AFP has the potential to lower the costs associated with these factors. The material used in this process would be in the un-impregnated state, i.e. raw fiber and resin; thus the cost to produce prepreg is eliminated. The process lays down single strands of fiber to the proper orientation within the part geometry; the material does not have to be prelaminated to orientation like prepreg does. This lowers the scrap rate. An entire preform can be stacked and stitched in one setup thus negating the need to cut, handle and stack a number of smaller parts. Also, this process offers the possibility to easily tailor the architecture of the structure to meet specific needs; this option has yet to be seen with prepreg tape technology. Although the process exhibits great potential, several technical uncertainties exist. Overall material properties must be analyzed for the baseline sabot fiber/resin system. Fiber straightness in the final part is of major concern in the sabot; this issue needs to be addressed. Also, full up sabots would need to be manufactured and tested, both in the laboratory and ballistically, for structural integrity in field conditions.

PHASE I: Determine the feasibility of Automated Fiber Placement by fabricating and testing sample panels. Samples of several material systems will be made with the AFP process and tested against samples made by the current prepreg process. Some samples will be analyzed for their overall integrity and others will be used for mechanical testing. Process parameters will be optimized and a downselect to one material system will be made.

PHASE II: Full scale sabot preforms will be made via the AFP process. These parts will be subjected to destructive laboratory testing for mechanical properties and overall integrity. Should modifications be required, the process will be tailored to the desired architecture. Finally, a group of twenty sabots will be made to the optimized process. This parts will be assembled into full-up cartridges and ballistically tested for structural performance.

POTENTIAL COMMERCIAL MARKET: The AFP process is especially well adapted for the economical manufacture of composite components that have complex shapes or that are subject to complex loading. Examples are housings for aircraft components, mounting blocks, prostheses devices, bicycle wheels, automobile or aircraft seat frames, springs, musical instrument components, etc. In some instances, a single AFP produced part could replace an assembly of multiple parts in the current state of the art. A wheel chair frame is an example of something that could potentially be made as a single piece by the AFP process. A multitude of potential applications exist in the medical, transportation and recreational industries where expensive materials are used and weight reduction is important.

Mission Relevance: In the current KE cartridge utilizing a composite sabot, the sabot accounts for approximately 46% of the overall cost of the round. By utilizing the AFP process, material and manufacturing costs would be lowered; it is estimated that a 25 - 30% savings can be attained. Also, the flexibility features of the AFP process allows the designer to tailor the part more readily to meet exact needs. As new KE cartridges come under development, both of these issues will allow the Army to field ammunition which meets the exact needs of the user at a reasonable cost.

A95-012TITLE:Passive Shielding for Low Frequency Magnetic Fields

CATEGORY: Exploratory Development

OBJECTIVE: The intent of this research project will be to design and test a lightweight material to shield low frequency magnetic fields (DC - 10 KHz), emanating from the barrel of an electric gun. This resultant shielding material could be used in other applications, which generate high level magnetic fields at low frequencies.

DESCRIPTION: Systems or facilities hardened to withstand electromagnetic environment effects usually require high-quality electromagnetic (EM) shielding over a broad frequency band. At low frequencies, this is especially a problem for magnetic energy. Usually the low frequency magnetic field shielding requirements involve thick magnetic materials, which drastically increases both the system cost and weight. At present, electric gun barrels use laminated steel to shield these low-frequency magnetic fields. These laminated steel structures add considerable cost and weight to these barrels. Also, the efficiency of the barrel is effected by these steel laminated structures. There is a need for the development of a lightweight material that can be easily installed and maintained that can provide high-performance shielding for electric gun barrels. In the past few years there has been some advancements in the developing of lightweight material, which could be quite useful in the electric gun technology. A material known as Thin-Shield has been developed and tested and results show that it has the shielding properties needed in the proper shielding of electric gun barrels.

PHASE I: Design, develop, and test a shielding material to provide a appropriate shielding electric gun barrels and can be used for power utility application. The shielding will be designed to be used as an outer layer to an existing electric gun barrel. The design criteria will be to provide the shielding with minimum reduction in barrel efficiency (which effects overall system efficiency), minimize shielding weight, thus help minimize barrel weight, and at a lower cost then existing shielding material. Subscale testing will be performed on a test sample to verify that the test sample meets the design requirements before applying the material to the electric gun barrel. The tests will be conducted in accordance with applicable military standards.

PHASE II: The next set of tests (provided material meets design criteria) will be large scale testing where an electric gun will be wrapped with the material and characterized for shielding effectiveness and overall barrel performance. After testing of material for electric gun applications, the material will be tested for power utility applications. Testing will be done by shielding a power utility buss room with the material designed to lower the magnetic field level from approximately 200 milli-gauss (typical level measured in a buss room) to 2 milli-gauss.

POTENTIAL COMMERCIAL MARKET: The technology developed under this program will provide a low cost shielding for schools, residential, office buildings, and any other structures where people would be exposed to undesirable magnetic field levels. The shielding would be made available to the utility companies as well as the general public. The technology would provide the military with a low cost shielding material for vehicles, electric gun barrels, or any other device where magnetic field levels are a hazard to personnel.

A95-013TITLE:Cubanes - Super Explosives and Potential Pharmaceutical Intermediates

CATEGORY: Exploratory Development

OBJECTIVE: The Cubane molecule shows great potential for both military and pharmaceutical applications. The objective is to develop polynitrocubanes as super explosives and polyfunctionalized (with groups having medical potential) cubanes as pharmaceuticals.

DESCRIPTION: Under ARDEC Tech Base Program, a focused effort is on-going to synthesize octanitrocubane, which is expected to provide about 25-30% more explosive output than LX-14, the Military's most powerful current explosive formulation. Initial screening of cubanes, by National Institute of Health, with a variety of functional groups has shown that these molecules have a strong potential to serve as beneficial pharmaceuticals, viz. as antiviral/anti-AIDS and anti-cancer compounds, without any toxic effect to normal living cells. Specifically, dipivalyl cubanes showed moderate anti-HIV activity and one of the diphenyl cubanes showed moderate anti-cancer activity. The

purpose of this SBIR is to develop appropriately identified cubane derivatives that can be nitrated to yield polynitrocubanes (super explosives) and also evaluated for new pharmaceuticals.

PHASE I: Conduct a detailed literature search and computer modeling studies to select cubane derivatives for nitration as well as for use as potential anti-viral/anti-AIDS and anti-cancer compounds.

PHASE II: Synthesize the target compounds for nitration and conduct an in-depth study of their therapeutic properties.

POTENTIAL COMMERCIAL MARKET: The unique and very challenging chemistry of cubane intermediates which is being developed at ARDEC, for the synthesis of new, more powerful explosives is playing an important role in the search for cubane -based pharmaceuticals. The above narrative clearly points out the commercial potential of this topic. Successfully prepared cubane derivatives which pass as pharmaceuticals can be scaled-up and medically tested. There is an anticipated substantial pay-off of this research to the civilian economy.

References:

1. P.E. Eaton et. al., J. Am. Chem. Soc., 1993., 115, 10195. 2. A. Bashir-Hashemi et. al., J. Chem., 1994, 59, 2132

A95-014TITLE:Improved Mounting POINT Stress Redistribution of Primary Loads in Composite Structures

CATEGORY: Exploratory Development

OBJECTIVE: Develop innovative solutions for stress redistribution at mounting points for primary loads in laminated advanced composite material structures.

DESCRIPTION: The need for improved distribution of primary stresses at mounting points in laminated advanced composite structures has been identified. Design methodologies for laminated composite structures often require global overdesign of a structural member due to the high local stresses experienced at mounting locations for primary loads within the structural member. The development of inexpensive, readily producible local strengthening would yield a greater degree of structural efficiency and reduced weight of primary vehicle structure.

PHASE I: Identify and propose innovative solutions for stress redistribution at mounting points in laminated composite material structures. Perform preliminary analyses and feasibility studies on proposed solutions.

PHASE II: Design, analyze, fabricate and test innovative composite laminate specimens displaying increased stress redistribution efficiency at primary load mounting points in laminated composite material structures.

POTENTIAL COMMERCIAL MARKET: The improvement in the design and fabrication of composite structures resulting from this research has significant potential for future application in primary automotive structures.

A95-015TITLE:Explosively Bonded Armor Materials

CATEGORY: Exploratory Development

OBJECTIVE: (1) Demonstrate the capability to explosively bond dissimilar armor materials to form a high performance composite of titanium and ultra high hardness steel. (2) Conduct ballistic testing of explosively bonded armors to establish baseline performance relative to conventional armor systems. (3) Establish manufacturing parameters to transition the process to large scale production of these armor arrays.

DESCRIPTION: This effort would establish the applicability of explosively bonded manufacturing techniques to high performance composite armor materials. The use of ultra high hardness steel as an armor material has been demonstrated; however, its use as a structural material is very limited because of its hardness, difficulty in welding, and cracking issues. Titanium is a good structural material with relatively high ballistic performance. The combination of these materials should yield an excellent and economical armor array taking advantage of each components strengths.

PHASE I: (1) Establish baseline parameters to develop sample explosively bonded composites and conduct physical testing to characterize the bond. (2) Develop test samples (nominally 12 inches square) to demonstrate the viability of the process and further characterize the bond quality. (3) Deliver samples to TARDEC for ballistic testing

of bonded arrays against small caliber threats to establish V50 data for comparison to conventional armor systems. (4) Submit quarterly progress reports documenting program activities and cost/schedule performance.

PHASE II: (1) Develop manufacturing parameters for production of bonded systems. (2) Conduct a study to determine physical size limitations of the explosive bonding process to establish applicability of bonded systems to either structural or applique armor configurations. (3) Submit quarterly progress reports documenting program activities and cost/schedule performance.

POTENTIAL COMMERCIAL MARKET: Effective bonding of dissimilar materials, such as titanium and steel, will provide substantial dual-use benefits to a number of industries. An example would be bonding in high temperature environments such as automotive engines. Application of this technology to structural steel or titanium structures where performance requirements dictate specific weights and wear or corrosion criteria. (The Japanese are currently using roll bonded titanium clad steel for corrosion protection in sea water environments.)

A95-016TITLE:Wide Bandgap Gallium Nitride (GaN) Semiconductor Technology

CATEGORY: Exploratory Development

OBJECTIVE: Develop high power GaN device technology for the millimeter wave (MMW) and optical sources.

DESCRIPTION: Devices fabricated from GaN have potential to operate at millimeter wave frequencies and demonstrate blue wavelength laser diodes with higher power than those made from traditional narrow band gap semiconductors. If these capabilities can be realized, the technology can be used to build ultra-broad radar & highpower MMW communications. Blue laser diode arrays will allow high power direct pumping of optical countermeasures (OCM) sources, another critical Army need. The robust nature of this material allows for the generation of large quantities of power without the need for external cooling. Thus, devices can be used by special operations forces (SOF) in remote theaters or in other applications where portability is critical. Toward these ends, technical barrier problems in material & process science, fabrication & testing must be surmounted to successfully demonstrate devices.

PHASE I: Should result in plans for surmounting critical deficiencies existing in the state of the art including designs for proof of principle device/s.

PHASE II: Should result in the fabrication and testing of prototype device/s based on technology developed during the course of Phase I.

POTENTIAL COMMERCIAL MARKET: This technology promises dual-use benefits for a wide range of sensors, including medical and navigational sensors. Devices could be used for pumping of commercial light sources, high performance communication links, displays, adverse weather landings, and police operations.

A95-017TITLE:Optical Modulator for Variable Doppler Frequency Offset of Wideband Microwave Radar Signals

CATEGORY: Exploratory Development

OBJECTIVE: Research and develop an optical modulator capable of variable doppler frequency offset of wideband microwave radar signals.

DESCRIPTION: Optical processing of wideband microwave signals offers the potential for improved performance and reduced system complexity, size, and cost when compared to RF signal processing technology. This is particularly true for wideband microwave radar signal processing applications where signal fidelity, dynamic range, and doppler processing are driving requirements. Using current technology, modulation/demodulation of laser beams using wideband microwave signals is practical, as is the optical amplification and delay of these signals in optical fibers. An important extension of this technology addressed by this research topic is the addition of doppler signal processing capability using purely optical means. Consequently, the objective of this effort is to research and develop an optical modulator capable of effecting a precisely variable doppler frequency offset on a wideband microwave radar signal carried by a modulated laser beam contained in an optical fiber. The technical goals for the optical modulator are as

follows: 1. Optical system interface: compatible with Erbium optical amplifiers. 2. RF signal characteristics: a) Frequency Bandwidth: >16 GHz b) Dynamic range (noise floor to input 1 db compression): >40db c) Gain due to optical modulator: >-10db (0 db preferred) d) Gain variation over frequency and temperature range: <1.5db e) Spurious products: -35 dbc or lower f) Doppler frequency range: +/- 500 kHz g) Doppler frequency set-on precision: +/- 20Hz h) Doppler frequency input bandwidth: 10 kHz 3. Operating temperature range: 0 to +50 C 4. Reduced size, power requirements and cost compared to RF 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/or laboratory investigations on the design and performance of critical components to demonstrate the feasibility and practically 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 optical modulator 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: The proposed research and development effort has extremely wide commercial application to wideband microwave signal processing functions in military and commercial radar and communication systems. Examples of commercial doppler processing radar system applications include vehicular collision avoidance, weather, law enforcement, industrial robotics, airborne and space systems.

A95-018TITLE:High Frequency Solid-State Devices

CATEGORY: Exploratory Development

OBJECTIVE: Develop advanced high frequency solid-state millimeter and submillimeter-wave/terahertz and quasi-optical technology.

DESCRIPTION: Small, highly functional and low cost high frequency electronic devices are needed to support emerging thrusts in electronic warfare, communications and digitization of the battlefield. Devices are needed to improve sensor performance for use in all-weather and day/night operations, and enhance target acquisition and situational for both stationary and mobile platforms. Applications for individual small signal, low voltage devices would include man-portable personal communications and object identification. High power devices as part of active device grids or alternative power generation schemes are needed for communications, electronic warfare and cooperative targeting. Control devices are needed for electronic scanning for agile beam steering, target and signal acquisition.

PHASE I: should result in the development of new solid state device concepts and techniques to achieve high frequency performance with increased efficiency and functionality. Complementary analysis, modeling and testing will be used to facilitate development and conceptual design through simulation and evaluation of performance. A proof of concept demonstration is desirable.

PHASE II: will result in the development of the proposed device or technology. Effort will be based on the results obtained in Phase I and lead to a full prototype for demonstration and evaluation. An analysis and evaluation of actual performance will be performed and specific limitations identified. Effort should be consistent with business plan, investment strategy and complementary product development.

POTENTIAL COMMERCIAL MARKET: Lower cost high frequency devices will have enormous impact on wideband wireless communications and local area networks, vehicular sensing, telemetry and collision avoidance, remote identification and tagging, direct broadcast and satellite communications and landing aircraft in zero visibility.

A95-019TITLE:Computer Aided Design System for Photonic Integration of Optoelectronic Circuits

CATEGORY: Engineering Development

OBJECTIVE: To develop a user friendly, analysis and design tool for the computer aided design (CAD) of optical circuits consisting of optoelectronic components and passive optical connecting structures. The power efficient integration of optoelectronic components is a major technology roadblock to optically controlled phased array systems for mobile and cellular communications.

DESCRIPTION: The development of a CAD system for the optical analysis and synthesis activities in designing optical paths connecting optoelectronic components would have a major impact on the development of integrated optoelectronic circuits for a wide variety of communications, signal processing, and radar applications. The control of optical modes throughout a long, complex optical path through active and passive optical components, through optical waveguide elements, and through optical fiber segments, is critical to avoiding optical losses and spurious reflections in practical optoelectronic circuits. Computer algorithms for full wave optical propagation exist, but are too computationally intensive for iterative design procedures. Less accurate algorithms exist for matching the mode structure in optical components, but lack user interfaces which would facilitate use by circuit designers. A user friendly CAD system is needed which will permit the use of time efficient codes for optimizing the design, with computationally intensive algorithms reserved for fine tuning and final checking. The CAD system should be compatible with commonly used electronic CAD systems, with the capability of being incorporated ultimately in a combined electronic/optical CAD suite.

PHASE I: Design and analyze a CAD system for design of long, complex optical paths through integrated optical elements. Develop a graphical user interface for specifying the circuit structure.

PHASE II: Develop and test the CAD system, incorporating appropriate optical simulation and analysis tools.

POTENTIAL COMMERCIAL MARKET: Major impact on commercial optoelectronic and optical circuits, particularly for communications.

A95-020TITLE:Near Monolithic Integration of Optoelectronic Circuits for Control of MM-wave Phased Array Antennas

CATEGORY: Exploratory Development

OBJECTIVE: To develop efficient integrated circuit designs for controlling phased array antennas, capable of low cost monolithic fabrication processes.

DESCRIPTION: Recent advances in the research of optoelectronic circuits have demonstrated the capability to control mm-wave phased antenna arrays using an optical heterodyne scheme, with dramatic potential impact on the problem of communications-on-the-move on the digitized battlefield. The integration of these circuits into nearly monolithic modules will increase efficiency and signal-to-noise ratio, decrease spurious optical reflections and vulnerability to vibration and temperature fluctuation, and reduce cost through high volume fabrication processes. In particular: fast, efficient optical detectors for moderate optical powers have been demonstrated to mix the heterodyne optical signals to produce RF and narrow linewidth DFB semiconductor lasers have been locked with phase locked loops to produce dual optical signals of moderate intensity offset by an extremely stable frequency in the mm-wave range. Proposals are solicited for the near monolithic photonic and electronic integration of these circuits for an architecture using 1300 nm or 1550 nm optical heterodyne signals over optical fiber to control antenna elements at 20-60 GHz RF. Novel techniques to minimize on-chip electrical power requirements and complexity at the detector module and to maximize the signal-to-noise ratio are encouraged. Packaging and integration of multi-chip modules should be considered.

PHASE I: Develop preliminary design of circuit. Analyze circuit for signal-to-noise, efficiency, and power issues. Demonstrate feasibility with a breadboard circuit.

PHASE II: Develop and test the integrated circuit module capable of insertion into a phased array architecture.

POTENTIAL COMMERCIAL MARKET: These modules would have direct application in commercial mobile satellite and cellular communications systems.

References:
1. PSAA-IV The Fourth Annual ARPA Symposium on Photonics Systems for Antenna Applications (1994), ARPA-TIO. Semiconductor Optoelectronic Devices, P. Bhattacharya, Prentice Hall (1994).

A95-021TITLE:Advanced Integrated Optic Filters

CATEGORY: Exploratory Development

OBJECTIVE: To develop advanced integrated optical filters for use in high performance fiber optic communication networks.

DESCRIPTION: Integrated photonic subsystems are required for application to point-to-point fiber optic communication networks, teleconferencing, and optical control of phased-array antennas. Wavelength division multiplexing (WDM) has been proven to be an effective approach to exploit the efficient routing of tremendous information capability of optical fibers. However, efficient routing of multiple signals remains a critical issue that limits the performance of planned networks. Current routing of optical signals is accomplished through optoelectronic components that are lossy and that degrade signal to noise levels.

Fiber optic communication networks are expected to provide revolutionary improvements in information transport and processing. Wavelength division multiplexing is a proven approach for exploiting the capability of the optical fibers. With use of a limited number of optical channels, transmission rates in the order of Terabit/sec can potentially be realized without incorporation of expensive, high speed electronics. Of paramount importance for the proper utilization of such networks is the efficient routing of optical signals to different channels. Through use of multiple laser sources, it is possible to transmit multiple channels on a single fiber. However, the routing of optical signals requires cross-connecting of channels by means of an optical filter. An ideal filter would be compatible with single-mode fibers, narrowband, tunable, and low loss. Such optical filters are not presently available.

PHASE I: Demonstrate the operation of a tunable, narrowband integrated optical filter for use in single-mode optical fiber communication networks. Novel photonic devices based on the electro-optic effect or on non-linear optics are to be considered.

PHASE II: Optimize device performance of the tunable, narrowband integrated optical filter and demonstrate a low cost fabrication process compatible with modern fiber optic communication networks.

POTENTIAL COMMERCIAL MARKET: The role of optical fiber networks will be expanding rapidly in commercial sectors during the next decade. Greater information handling (data, video, voice) will be performed optically. The potential commercial market for tunable, narrowband integrated optical filters for routing of multiple signals into different channels is quite large. A low-cost, reliable process for fabricating such filters would have a significant impact on this entire technology.

References:
1. C.A. Brackett et al, "A Scalable Multiwavelength Optical Network," IEEE J. Lightwave Technology, LT-11,736(1993)
2. W.R. Trunta et al, "Acousto-Optic Tunable Filters," Opt. Lett. 18,28(1993)

A95-022TITLE:Computer Aided Design of Printed Circuit Antenna Systems Using Suite of Optimized Algorithms

CATEGORY: Engineering Development

OBJECTIVE: To develop a fast, efficient computer aided design (CAD) system for the design of printed antenna circuits and arrays.

DESCRIPTION: An efficient, fast CAD system for printed antenna circuits would have a major impact on communications, radar, and seeker systems in the millimeter wave and SHF frequency ranges. Losses and directivity of

the antenna and feed system for very high microwave frequency systems have a dominating effect on the performance and power requirements of the entire electronic system. Current EM simulation engines require large amounts of time for the analysis of practical structures. A CAD system is needed based on a suite of algorithms, each of which has been optimized for particular classes of passive circuit elements. The resulting analysis would couple segments of the EM structure to provide the overall circuit parameters. Such an analysis would be very fast and would permit rapid synthesis of antenna circuits and arrays. Such a CAD system would permit the design of antenna circuits and arrays from an "electrical circuit" point of view rather than the traditional but time consuming and complex EM point of view.

PHASE I: Develop a plan for the CAD system. Develop a graphical user interface (GUI) for a user friendly system.

PHASE II: Develop the suite of algorithms and couple them to the GUI. Develop and test the CAD system.

POTENTIAL COMMERCIAL MARKET: Significant potential impact on the design of commercial communications and radar systems.

A95-023TITLE:Small Affordable Anti-Jam GPS Antenna (SAAGA)

CATEGORY: Exploratory Development

OBJECTIVE: Develop a GPS antenna with active anti-jamming protection, that is of the size, weight and cost magnitudes of current Fixed Radiation Pattern Antennas (FRPA).

DESCRIPTION: Currently, available GPS antennas providing anti-jam protection are not appropriate for Army platforms as they are large and costly. Under this topic, advanced microelectronic circuit and processor technology shall be applied to develop a GPS antenna that is equivalent in size, weight and cost as FRPA's and has anti-jamming performance as effective as Controlled Radiation Pattern Antennas. This program shall consider both broad and narrow band jammers. Adaptive techniques shall be investigated to null jammers based on feedback from a GPS receiver via digital interface. Applications to be considered include all Army platforms (soldiers, ground vehicles, helicopter and fixed wing aircraft).

PHASE I: Design an active anti-jam antenna in the size and cost magnitudes of a conventional FRPA GPS antennas.

PHASE II: Build and demonstrate the antenna and associated electronics. For this phase, a brassboard prototype is acceptable. The contractor will present a plan for miniaturization and design-to-cost. The Government will conduct a demonstration of the brassboard system in the lab and on an aircraft.

Phase III: Under this phase, the contractor will package the antenna and associated electronics in a production configuration. The government will undergo a full qualification program of the antenna.

POTENTIAL COMMERCIAL MARKET: GPS is emerging as a major positioning and navigation system for commercial aircraft (enroute and landing), maritime navigation, trucking, surveying and recreational purposes. Coincidental interference (for example from cellular telephones) and intentional jamming (terrorist) is perceived to become a problem as the civil sector develops its dependency on GPS. Technology resulting from this program can be applied to reduce the effects of interference and jamming in a cost effective manner.

A95-024TITLE:Complementary High Power RF FET Development for High Efficiency Amplifiers

CATEGORY: Exploratory Development

OBJECTIVE: To design and fabricate a pair of complementary Field Effect transistors (FET), N-channel and P-channel, capable of switching at frequencies sufficient to provide switched mode amplification of frequencies up to 1Ghz, and delivering 250 to 300 Watts of RF power.

DESCRIPTION: Army EW systems have limited prime power reserves due to their mobility requirements. Current transmitting systems are inefficient, usually averaging less than twenty percent efficiency. There exists several amplifier topologies that can achieve greater than eighty percent efficiency, these are the switched mode amplifiers

such as Class D and E. Current transistor technology is focused on linear amplification applications, this limits the useful frequency range when used in switched mode amplifiers. A potential solution is the creation of devices specifically designed for switched mode applications. The transistors will be designed specifically for switched mode high efficiency amplifier topologies such as Classes D, E and S. Linear operation of the devices is considered irrelevant. The goal will be devices capable of delivering 250 to 300 Watts of RF power in a Class D push-pull configuration. FETs are the device of choice because of their high input impedance and ability to conduct current in both directions. The material used in the design is not specified, however, both the material and the processing required must be commercially available. This effort shall improve the efficiency of EW systems by positively impacting the system power requirements, system size and weight.

PHASE I: The contractor shall investigate designs for the devices that may satisfy the objective. The potential device designs shall be simulated using programs like SUPREM and PISCES. A final report will be generated presenting the most favorable designs indicating the strengths and weaknesses of each approach and any technological barriers that may hinder fabrication.

PHASE II: The contractor shall fabricate and test the best design(s) for the new device. The program may be segmented by fabricating lower power test versions. For example the first devices may only be rated at 50 watts, followed by a 100 watt version, and finally a version that meets the requirements of providing greater than 250 watts of RF power. The programs segmentation is to reduce risk both technically and financially. Deliverables shall be transistors developed, test data, design data, simulation results, test amplifier, and a final technical report.

POTENTIAL COMMERCIAL MARKET: There is a large market within the EW community for high efficiency broadband amplifiers. Commercial possibilities would be in commercial broadcasting, instrumentation amplifiers and the exploding telecommunications industry.

A95-025TITLE:Conformal Antennas for Soldier C4I

CATEGORY: Exploratory Development

OBJECTIVE: Develop low power, high data rate, omni-directional C4I for the individual soldier.

DESCRIPTION: A need exists for wide-band, high data rate communications capabilities for the soldier in the field. A wireless LAN solution that does not require directional antenna pointing for the soldier on the move is desired. Conformal antenna technology embedded in the soldier ensemble can solve the problem and also provide a relay capability for soldier paging and reporting.

PHASE I: Will conduct research and investigate and propose solutions for the development of an individual paging and limited messaging capability without resort to highly jammable satellite transmission. Maintaining suitable antenna gain for a moving individual in omni-directional and various skeletal attitudes is a major technical barrier to this realization. The initial investigation will establish minimum gain ratios a function of activity and body orientation that is consistent for low rate data exchange and less than 10 M/W power consumption for portable systems.

PHASE II: Refine the recommended solution and proceed with advanced development of prototypes.

POTENTIAL COMMERCIAL MARKET: Commercial applications include high data rate multi-media uses for personal digital assistance in areas of visual teleconferences, travel mapping, way point/best route prediction and personal tracking and safety. Dual use of this technology would also include use by forest rangers/fire fighters, riot peace keepers, police and drug enforcement agencies and border patrol. A soldier walking through the woods on patrol, a launch crew or a vehicle crewman would benefit from the omni-directional capability.

A95-026TITLE:Advanced Hermetic Metal Coated Optical Fibers for Precision Alignment for Optical Applications

CATEGORY: Exploratory Development

OBJECTIVE: To develop in line processing of magnetic coated optical fiber that will allow for an optical-fiber package precision wound on a reel-out bobbin to maintain a small-free standing stable package in tethered vehicle which is of special importance in military defense systems. The bobbin maintains the convolution in a precision wound package to prevent snags during payout. A magnetic coating on an optical fiber insures that the fiber is held in the proper position during winding. This provides a constant force to support the fiber during storage and a constant peel force during deployment.

DESCRIPTION: Typically, a conventional fiber is held in its precision wound spooled state by means of a sticky organic adhesive. This adhesive can cause mechanical fatigue to a precision wound fiber bobbin which can cause degradation of the optical fiber and even cause physical failure of the fiber during deployment. Magnetic coatings on optical fibers have the potential to eliminate many of the severe deficiencies of an organic adhesive system. Such problems as non uniform peel-out rates due to viscosity changes, fiber strength degradation, organic plastic deformation, "fishing snags" (fiber knotting or kinking) and environmental effects can be minimized by the use of magnetic coated optical fiber. Magnetic coating on optical fiber can also lead to faster fabrication of spools, which is presently a costly drawback when using organic adhesives. Magnetic coatings provide a hermetic, high strength magnetic fiber which eliminates the common problem of an adhesive-based system and will provide a practical and also a cost effective means of producing a reliable, fast payout spool.

Deployment of optical fiber on payout spools on moving air, land, water craft has been utilized as a means to establish a fast communication link. This technique can be use for a variety of military and commercial applications. This has been particularly useful in rapid missile payout systems (e.g. Non-Line -Of-Sight Arms Weapon -NLOSCA) where optical fiber is spooled out at a very high rate of speed from a missile. Optical fiber is physically connected to the missile during its flight to provided a bi-directional tap-proof communications link to exchange critical guidance and intelligence information between the ground station and the missile.

This approach will use a thin film ferromagnetic metal coating on the fiber. There are several approaches to using magnetics to cohesively bundle such coated fiber into a sturdy skein, each taking advantage of the wide range of magnetic properties. Advanced magnetics offer an opportunity for enhanced performance and novel application of optical fibers. These coatings can potentially help in storage, self-life and deployment as well as overall reliability of optical fibers for military applications.

This advanced technology will also have outstanding potential for generation of micro or milliwatt power for micro-opto electronic devices. Magneto-optics relates the influence of magnetic fields on optical properties of light, magneto -optics is characterized by electromotive force developed by magnetic means for dual purpose generation of micro power (milliwatts) and modulation of light via electromotive force on optical fiber light for wavelengths 1.3-1.5 microns for photonics and opto-electronic devices.

Additionally these coatings can lead to several other applications. The property of the magnetic coatings has application for systems requiring precision alignment via magnetic attraction of fiber to metal ferrule sleeves such as optical connectors. It also has application to the production of novel electro-optic and related devices and subsystems.

PHASE I: In Phase I, a thorough exploratory investigation and implementation of a magnetic coating on optical fiber will be conducted. This can include, but not be restricted to, the following: initial sample of a magnetic coated fiber, magnetic properties of magnetic coated fiber with respect to properties pertinent to precision alignment, production on a magnetic coated optical fiber bobbin, analysis of the spooling mechanism using magnetic coatings, feasibility, and final analysis and recommendations. Magnetic coated optical fiber will be characterized for their magnetic and optical properties.

PHASE II: In Phase II, a continued analysis based on Phase I conclusions will be performed. This will include implementation of improvements to the magnetic coated optical fiber payout system, analysis on actual payout bobbins, preliminary analysis of payout using magnetic coated optical fiber, actual payout testing and final analysis and conclusions related to commercial feasibility.

POTENTIAL COMMERCIAL MARKET: This magnetic coated optical fiber will have potential uses in magneto-optic disk head technologies, data storage, and novel magneto-optic transistors. Magnetic coated optical fiber

also has the ability to generate electrical current when exposed to high magnetic fields. This property will result in various lightweight motors and generators commercial applications. Also space based applications and sensor technology use are anticipated. Magnetic coating of optical fiber and analysis of spooling mechanisms has potential commercial application in areas where high strength fiber and a cost effective means of fast payout is needed such as in commercial, recreational equipment fishing and research as well as other areas.

A95-027TITLE:Phase Locking of Semiconductor Lasers for Optical Generation of Millimeter Wave Sources Greater than 60 GHz

CATEGORY: Exploratory Development

OBJECTIVE: The objective is to investigate means for optical coherent heterodyning to create microwave signals for use in wideband analog transmission and phased array antenna systems. This will require demonstration of, but not be restricted to, the following: phase locking of semiconductor distributed feedback lasers with a stable upconverted frequency range greater than 60 GHz; utilizing lasers with orthogonal polarizations to allow for transmission over optical fibers prior to heterodyning or alternative techniques; external modulation of one of the lasers; and maintaining polarization separation during fiber optic transmission. Semiconductor lasers also make it more viable to integrated in a monolithic package. The overall goal is to monolithically integrate these optical elements in a single device. This would provide a lightweight, low cost, robust, technically superior optical system for the generation of microwave/millimeter wave energy.

DESCRIPTION: CECOM is developing technology leading to the demonstration of optically controlled phased array communications sub-systems for Army communications on-the-move (OTM). Carriers frequencies might vary from 6 to 60 GHz with data rates of 2.4 Kb/s to 155 Mb/s or more. Adaptive multiple antenna beams and adaptive null capabilities will ultimately be required. Major emphasis is being placed on a high degree of photonic integration to develop modular, scaleable and "frequency independent" subsystems for multiple applications and to reduce size, weight and cost, thus leading to a practical realization for Army tactical systems. Near term emphasis is on optical phase control. The systems support the Army initiative to "digitize the battlefield." CECOM has already initiated Research & Development contracts in support of some aspects of these sub-systems.

PHASE I: I Phase I, a thorough exploratory investigation and modeling will be conducted to experimentally verify the feasibility of the objective. This will include, but not be restricted to, the following: phase locking techniques for optical heterodyning, design of control circuitry for phased locking scheme, linewidth requirements, system requirements, polarization issues, modeling and design in support of coherent optical communication, and experimental verification. A thorough investigation of Distributed Feedback parameters will be conducted to determine fundamental limits of phase and frequency.

PHASE II: In Phase II, a continued analysis based on Phase I conclusions will be performed. This will include implementation of an optical heterodyning system leading from discrete optical devices to a highly integrated photonic device. An end result would be the incorporation in a prototype phased array antenna system, and a fielded demonstration of prototype system.

POTENTIAL COMMERCIAL MARKET: This concept will have potential uses in long haul communications systems, satellite applications. Applications include both SATCOM OTM (on-the-move ground terminals) and terrestrial communications OTM.

A95-028TITLE:Thin Film Semiconductor Placement on Host Substrates

CATEGORY: Exploratory Development

OBJECTIVE: To develop processes, materials, and equipment that allow high-speed, automated placement of thin-film semiconductor devices onto integrated circuit and multichip module (MCM) substrates.

DESCRIPTION: Recent developments have led to the capability of separating an epitaxially grown semiconductor device from its substrate while retaining the electrical characteristics of the device. This process, known as epitaxial lift -off (ELO), allows the combination of different semiconductor material systems when the lifted-off device is transferred to a host substrate that can be of difference composition than the growth substrate. With this technique, compound III-V semiconductors (such as GaAs) can be grown in a process optimized for the particular material, while electronic processing circuitry can be created in a process optimized for its material system (such as Complementary Metal Oxide Semiconductor (CMOS) silicon). The materials are brought together only after the material/device growth is complete, thus allowing hybridization at a semiconductor device/integrated circuit level. What is needed is a precise, automated method of transferring thin film semiconductor devices/circuits that have been "lifted off" onto the host substrates.

PHASE I: Examine material combinations and processes for transfer of thin film semiconductor ELO devices from a carrier to an integrated circuit substrate. Determine best release mechanism for the device to be released from the carrier (mechanical, thermal, ultrasonic, etc.) Examine feasibility of placing thin film devices onto or into a "smart" multichip module substrate. Investigate potential for automated device testing following placement. Develop a system concept document describing an automated machine that can deposit 30 devices/minute or 10 circuits/minute onto a host substrate, with 5 micron resolution and 1 micron repeatability. Include considerations for clean room environment, cost of equipment, modularity, and adaptation of currently available systems or systems under development.

PHASE II: Design and fabricate a prototype placement machine based on the system concept developed in Phase I. Develop all software, machine vision, and CAD interfaces needed to perform system functions and interface with one human operator. Test prototype system on multiple runs of different ELO devices and substrates. Benchmark system to determine capabilities/limitations, and investigate opportunities for improved performance and lower system cost. Canvass industry for potential beta test sites.

POTENTIAL COMMERCIAL MARKET: The equipment developed under this SBIR would be an enabling technology for the availability of high performance integrated circuits and MCMs. The market for MCMs is expected to increase at least 10-fold by the end of the decade. The increased functionality to individual integrated circuits will allow compact packaging of military, commercial, and consumer products with more capabilities at lower cost.

A95-029TITLE:<u>High Efficiency Input/Output Couplers for Optical Waveguide Devices</u>

CATEGORY: Exploratory Development

OBJECTIVE: Develop high efficiency optical couplers for guided wave photonic devices and optical integrated circuits (OICs)

DESCRIPTION: For many applications such as optical gyroscopes, TR modules and high density signal processing very high efficiency, low cost couplers are required. Differences in mode profiles, index matching and applications requiring out of plane coupling between optical fibers, semiconductor waveguides or new material systems such as electro-optical polymers make the problem more difficult. The key desirable features are low loss <1dB), versatility in processing for application to hybrid systems (particularly semiconductors and polymers), low cost, compact size, and adaptability for either spatially distributed or single mode coupling.

PHASE I: Design and demonstrate basic concept for new optical coupler techniques. Evaluate performance and analysis results for comparison to conventional techniques. Semiconductors and EO polymers should be particularly considered in the wavelength range of 0.8 -0.9 and 1.3 - 1.5 microns.

PHASE II: Optimize coupler design for selected application specifications and demonstrate technique. Analyze and compare tradeoffs for performance, material systems, and architecture.

POTENTIAL COMMERCIAL MARKET: A wide range of commercial applications are currently being developed for optical gyroscopes, biosensors, multichip modules for computer interconnects, T/R modules for communications links, and fiber links for video networks. In all of these application performance, cost, and size are critical issues which are in large measure driven by capability of electro optical system components coupled together with optical fibers. Improvements in coupling technology, particularly for hybrid system will greatly impact near term

insertion into these commercial markets. In many cases the coupling technology will make the difference in the ability to use a particular optical material or electro optical component in these systems.

A95-030TITLE:Agile Laser Protection for Combat Vehicle Surveillance Vision Devices

CATEGORY: Exploratory Development

OBJECTIVE: To develop agile laser protection technologies for surveillance vision devices. These protection technologies must reject harmful laser radiation, independent of its wavelength, while allowing low energy scene illumination to pass through to the eye.

DESCRIPTION: The U.S. Army, Navy, Air Force, and Marine Corps consider the protection of the eyes of military personnel against laser radiation to be a priority objective. The human eye is most susceptible to laser radiation in the range of wavelengths from 400 to 1400 nanometers and must be protected throughout this region. The non-visible portion of this spectral range should be denied access to the eye by fixed attenuation. Transmittance in the region from 400 to 700 nanometers must be preserved to maintain vision under all conditions and illumination. Increasing the number or width of fixed attenuation bands in the visible spectrum will result in unacceptable degradation of the transmittance of visible light through the protective material. New concepts are therefore required. The effort sought in this solicitation is for new technological approaches to protect the eyes of combat vehicle crews, when using unity vision equipment, against emerging multi-wavelength and frequency-agile lasers. The basic desired attributes of the non-linear laser power limiting material/system include: capable of meeting minimum optical density requirements regardless of the angle of incidence of the laser radiation; response time for activation of attenuation of less than one nanosecond; recovery time from attenuating condition of less than 0.1 second; visual transmittance, both photopic and scotopic, of at least 50%; capable of resisting laser damage; and capable of functioning in temperature extremes (-40 Deg to 160 Deg F) and humidity extremes (0% to 100% RH).

PHASE I: The contractor shall investigate, design and provide a proof-of-principal demonstration of a novel agile laser protection technology meeting the requirements set forth in the project description. A final report shall be delivered.

PHASE II: The contractor shall fabricate, test, demonstrate, and deliver the protection approach developed in Phase I. A final report shall also be delivered.

POTENTIAL COMMERCIAL MARKET: Laser protection has enormous commercial applications for safety and health equipment due to the proliferation of lasers in laboratories, academia, and industry. Examples include protection for industrial machining activities, medical procedures, communications, and computing.

A95-031TITLE:Affordable Scanning Millimeter-Wave (mmW) Antenna Technology

CATEGORY: Advanced Development

OBJECTIVE: The Army has an inherent need to develop enabling radar technology that is both affordable and flexible with growth potential to address many radar requirements. An area that best demonstrates a need for both affordable and flexible technology is in the antenna assembly. Too many antenna technologies are limited to a specific operating band or use expensive components for scanning, transmitting, and receiving or have a heavy, bulky structure. Specifically we are looking for a planar antenna design that has a separate transmit and receive capability, a center frequency between 33 and 35 GHz with a technology growth potential to operate at higher frequencies (i.e. W band), a 2 GHz bandwidth, a narrow beam of less than 2 degrees that is vertically polarized. We desire scan capabilities of plus or minus 30 degrees at a 60 degree per second scan speed and a scan width that doesn't change with frequency. We also desire sidelobe levels that are greater than 20 dB, loses that are less than 2 dB and Voltage Standing Wave Ratio (VSWR) that is less than 1.5:1.

DESCRIPTION: An antenna is required to support the various missions associated with a target acquisition radar. These missions include moving and stationary target indication which suggest low antenna losses, a modest gain, a narrow beam, wideband operation, and polarimetrics.

PHASE I: This effort should study the various antenna technologies that can support the above specifications, emphasizing technology tradeoffs with respect to affordable and flexible architectures. There should be considerable reasoning in the selection of one antenna architecture over another. Identify areas of risk associated with the chosen architecture. Simulate and develop a preliminary design and describe the flexible features and upgrade path for this antenna structure. There should also be a cost breakdown for prototyping one antenna assembly for a Phase II effort as well as for a production cost for 1000 units.

PHASE II: Simulate, design, build, test and report on the chosen antenna structure from the Phase I.

POTENTIAL COMMERCIAL MARKET: An antenna structure that is both affordable and flexible and is associated with supporting radar technology may have vast commercial opportunities i.e. collision avoidance in the automobile industry.

A95-032TITLE:Artificial Intelligence Enhanced Information Processing

CATEGORY: Basic Research

OBJECTIVE: This topic solicits research in advanced information processing algorithms as well as hardware architectures which will support critical Army program areas such as fusion stations, ground stations, advanced sensor based robotics, and automated target recognition.

DESCRIPTION: The Army has a strong continuing interest in real-time information processing research as applied to single sensor, multi-sensor, and multi-sensor integration (fusion) station processing. Information processing includes those operations normally performed after signal processing, thus relating to higher levels of abstraction and lower "bandwidth" (measured in instructions per second) than those addressed by signal processing. Examples of information processing tasks include multi-sensor correlation, fusion, target tracking, situation assessment, target value analysis, etc. Information processing encompasses approaches that are both algorithmic and symbolic (based on artificial intelligence (AI)). Applicable research topics should relate to high-speed signal and information processing (particularly with AI based enhancement) for such systems as acoustic, radar, and electro-optic sensors in a single and multiple (homogeneous as well as heterogeneous) sensor configurations. This topic includes advanced processing architectures as well as advanced algorithms.

PHASE I: Information processing research yielding innovative algorithms or advanced processing architectures which are then simulated or otherwise shown to have potential in real-time processing applications.

PHASE II: Research resulting in the real-time implementation of Phase I algorithms and/or processing architectures which will show direct relevance to an objective interest area such as fusion stations, ground stations, advanced sensor-based robotics.

POTENTIAL COMMERCIAL MARKET: The technologies related to this topic, Artificial Intelligence Enhanced Information Processing, correspond strongly with a number of commercial or dual-use applications such as aircraft tracking and control for commercial airfields, intruder detection and tracking, manufacturing inspection, and intelligent highway system applications.

A95-033TITLE:Intelligent Information Presentation for a Helmet Mounted Display in a Synthetic Environment

CATEGORY: Exploratory Development

OBJECTIVE: To develop an innovative and intelligent information presentation for a Helmet Mount Display (HMD) as aircraft flight regimes change.

DESCRIPTION: Future methods of providing appropriate and timely information to the rotorcraft pilot via an HMD will require significant improvements to meet mission and pilotage requirements. Categories of information already

envisioned for the HMD display include flight, navigation, system, obstacle avoidance, virtual switching and warnings, and weapons status, and target acquisition. Research has shown that this volume of data leads to pilot information overload. Advances in intelligent information presentation as well as prioritization and filtering of flight mode information needs to be achieved to obtain an essential high level of performance during low altitude night operations. As the rotorcraft movers through flight modes such as hover, lowspeed flight, cruise, and maneuver the symbologies displayed should intelligently and automatically make the same timely information transitions. Manual mode selection of display information in use today was developed in the late 1970s. Manual mode selection does not take advantage of data bus and electronic cockpit monitoring systems that could provide automatic and intelligent information updates. Manual mode switching increases pilot workload and often results in unnecessary display icons that clutter the pilot's synthetic environment. Current technology does not provide the intelligent information presentation requirements necessary in future aircraft. Reduced pilot workload, safer flight envelopes, the encouragement of low-cost HMD development and use in the civil sector, and simpler pilot-vehicle interface with reduced switchology are all goals of this program.

PHASE I: Using several design principles for information display, identify and evaluate innovative flight and mission information mode switching concepts necessary for representative aviation mission. Then, using a baseline which is representative of current technology, select several candidate intelligent information prioritization/filtering techniques to demonstrate the potential increase in pilotage and mission effectiveness.

PHASE II: Preliminary evaluations of intelligent information presentation concepts for an HMD will be performed in both ground and in-flight simulation to verify improvement potential. Complete definition of intelligent moding characteristics of the most promising configuration will be verified in flight tests on helicopters with HMD systems.

POTENTIAL COMMERCIAL MARKET: This automatic moding HMD technology will have multiple applications in civil sectors in areas of emergency services including police, ambulance, forestry, and fire protection. Civilian resources are increasingly being tasked to monitor and assist in border surveillance, neighborhood surveillance, fire emergencies, highway patrols, forest protection, police reinforcement, and rescue service. Rotorcraft play a unique role meeting the civilian sector needs in all of these areas. These activities represent a growing market for rotorcraft; especially, in high population density areas. It is these high density areas where safety of flight issues are magnified and where intelligent flight moding will be most useful.

A95-034TITLE:Acoustical Sensor, Target Engagement, Environment And Performance Model

CATEGORY: Exploratory Development

OBJECTIVE: Methods are currently under development to increase survivability of friendly forces through the use of non-cooperative passive acoustical identification technologies. The objective of this task is to design, develop and implement an acoustical target, environment and sensor simulation model in order to investigate and quantify acoustic sensor performance under a variety of controlled and repeatable conditions.

DESCRIPTION: Non-Cooperative acoustics has especially high potential for assisting the army in the difficult problem of passive detection, classification and identification of various targets. Acoustics does have its limitations. Accurately modeling and estimating performance of these sensors is complex. Propagation of all acoustic signals are sensitive to atmospheric, meteorological and terrain variabilities. This is especially true in the case of the acoustic signatures of many types of targets of military interest. The problem to be explored poses several important technical challenges, among them: 1) Target signatures are inherently broad band and highly variable, 2) Acoustic propagation through the atmosphere and interaction with the earth's surface can greatly alter target signatures, and 3) Acoustical sensors may employ a variety of signal processing techniques as well as sensor configurations. These factors and others tend to complicate the analysis of acoustic sensor performance via traditional analytical methods. The output of this model will be a spectrum of figures of merit.

PHASE I: The contractor shall review and quantify all factors affecting acoustic emanation, propagation and detection. The contractor shall then make a determination of the factors to be modeled in this effort. The contractor shall also develop the system architecture concept and perform analyses, trade-offs and other analytical studies on the various factors. These should include but not be limited to engagement factors (i.e. Platform and trajectory data, initial

conditions, interference sources placement and qualities, terrain data(digital), and discrete objects), Propagation factors (i.e. Terrain, Multipath, Obscurants, atmosphere, meteorology etc.), and Sensor Information (i.e. sensor geometry, number, placement, characteristics and signal processing). In addition, the initial output figures of merit shall be developed and refined.

PHASE II: Implement the model using a modular approach, in order to provide statistically meaningful data with the various figures of merit developed. Test the discrete modules and the integrated system to verify adherence to theoretical and benchmark predictions (e.g. simulator laboratory testing). Exercise the system using realistic engagement scenarios. The Model will be used to calculate and output measures of performance for specific engagement scenarios of interest to the Government.

POTENTIAL COMMERCIAL MARKET: This model would have application to the commercial aviation industry, and to the FAA for studying airport noise levels in its ability to estimate noise levels under a given set of circumstances. It can also provide noise estimates to the transportation industry to assess noise related environmental impacts of highway construction and expansion.

A95-035TITLE:Soldier-Computer Interaction/Communications

CATEGORY: Exploratory Development

OBJECTIVE: Define methods and technology to address the total soldier-computer interface.

DESCRIPTION: Consistency and quality of the soldier/computer interface in a variety of operational scenarios is a must. To effectively communicate with emerging automation soldier comfort and assimilation must be maximized to minimize errors. To exploit the increased competence of the modern soldier and the power of automation, boredom, stress and fatigue along with specialized training needs to be reduced. A wide range of real time interaction is needed from the highly structured environment of the soldier in the fire fight world to the interface requirements of the various command post echelons.

PHASE I: Evaluate, select, and test current and evolving hands free technologies useful for man machine interface.

PHASE II: Refine the recommended solution(s) and proceed with advanced development. Integrate and assemble candidate technologies into a prototype and conduct live soldier tests to evaluate performance.

POTENTIAL COMMERCIAL MARKET: High potential for virtual reality and hands free interaction with computers in entertainment and commercial vehicle operations. Dual use applications in many manufacturing and real-time vehicle control situations (buses, aircraft, ships/ferries, trains, subway systems, etc.) that would benefit from a more natural presentation of multimedia data. Multimedia presentations include the simultaneous interaction of the human to live video, data, status, communications and controls elements. Special consideration is given to the technologies that can support multiple human status/well-being measurement and display with overlaid computer decision support presentation to reduce the investigator workload. The combination of technologies will be coupled in a cognitive manner to reduce the amount of superfluous and redundant information to ease the human interaction with computers/communications equipment.

A95-036TITLE:The Detection and Location of Buried Metallic and Nonmetallic Targets

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate the feasibility to detect shallow buried objects such as landmines.

DESCRIPTION: The desire is to detect and locate buried objects such as landmines. These objects are usually no more than 6 inches deep. The object may be metallic or nonmetallic and range in size from tennis ball size to 12 inches in diameter by 4 inches thick. There are no restrictions on the detection phenomenology. An experimental demonstration component of any proposal is desired. The detector may be man portable, vehicle mounted or airborne.

PHASE I: This phase should include thorough analyses that theoretically demonstrate the scientific soundness of the phenomenology to detect the objects of interest as well as related and supporting experimental or laboratory results.

PHASE II: This phase should emphasize field experiments and demonstrations designed to clearly establish the feasibility of the phenomenology to detect buried landmines in real soil and terrain conditions in the field. The proposal should also accommodate participation in blind field tests run by the government.

POTENTIAL COMMERCIAL MARKET: Mine detection technologies have broad applicability to other applications including road inspection, utility line and pipe detection, environmental remediatory hazardous waste detection, bare cleanup, and nondestructive testing.

A95-037TITLE:Miniature Multiple Sensor For Remote Surveillance

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate a small, lightweight, low power requirement multiple sensor package to enhance remote detection.

DESCRIPTION: Current remote surveillance sensors are typically packaged individually. If single sensors suites are employed, a knowledgeable forces can often defeat surveillance. To meet a variety of conditions and to preclude stealth attacks, a number of different sensors must be employed. The need for multiple ruggedized physical packaging and multiple power sources and transmission circuits increases the system weight, size, and cost. These limitations result in less convenient field usage. What is needed is a whole new class of integrated sensors suites with small unit coverages out to one kilometer and operating for several days on a small battery (or other power source). Cost should be low enough that sensors can be abandoned if need be.

PHASE I: Investigate the available and developmental state-of-the-art in overlapping sensors in the acoustic, radar, infrared, and optical portions of the spectrum. Project current state of development for several years into the future (probably production development time). Define the tradeoffs in power, coverage, sensitivity, size, security features, low detection probability, extrapolated cost, range, ruggedability and packaging, and so forth. Use modelling to select several configurations representing nominal optimization for several deployment situations.

PHASE II: The Army will select one of the configurations defined in the first phase for prototype development and demonstration. The contractor may elect to use REMBASS as the base system or use one of their own design.

POTENTIAL COMMERCIAL MARKET: Security surveillance systems are needed for almost all installations. These include nuclear plants, storage yards, warehouses, port facilities, prisons, governments buildings, olympic sites, and many, many more. Such are the times in which we live.

A95-038TITLE:Development of Real Time Ray Tracing Software

CATEGORY: Exploratory Development

OBJECTIVE: To create a fast, high power, computational tool that can provide the high resolution, complex scene geometry input necessary to drive FLIR sensor simulations. This tool, when installed on a powerful, modern, computer and applied to a highly detailed battlefield geometry model, will make it possible to generate truly realistic, electronic battlefield imagery as viewed through an existing or future design IR sensor.

DESCRIPTION: To construct an efficient, high resolution, ray trace imaging tool that can accept highly detailed complex geometry as input and produce real time results on a massively parallel computer. Complex geometry databases include terrain maps, trucks, tanks, buildings, trees (with leaves), roads, grass, etc. This tool should employ an algorithm that is easily run on multi-CPU machines having a UNIX operating system. This tool should be written in the C programming language.

Current technology employs polygon rendering algorithms with texture maps. Although this approach is fast (especially when combined with high speed polygon rendering hardware), it does not efficiently handle optical effects

such as shadowing, semi-transparency, and diffusivity. Polygons are great for modeling large flat structures; however, complex surfaces such as aircraft fuselages, Russian tank turrets, boat hulls, and terrain cannot be accurately modeled using polygons. The problem with these complex surfaces is that they have no flat areas and the number of polygons required to preserve their curvature is very large. It is the sheer number of polygons required that cause polygon based codes to slow down excessively or exceed software array boundaries.

The best illustration of this is a soccer ball vs. a sphere. If the patches on the surface of the soccer ball were flat, the ball would not roll perfectly on a flat surface. The sphere does not have any flat patches and therefore rolls perfectly. As the number of flat patches on the soccer ball is increased, the soccer ball approaches the sphere in behavior. If the number of patches is infinite, then the soccer ball becomes a perfect sphere.

PHASE I: Investigate combinatorial solid geometry (CSG) raytracing techniques to locate the best current algorithms and methodologies. Evaluate to determine any bottlenecks, scaling factors, distributed processing capabilities, and portability issues exist. Scaling involves any database complexity vs. performance coupling. Distribution involves how well does the algorithm vectorize and/or distribute across multiple processors and CPUs. Once the investigation is complete, formulate a methodology for testing new methods and algorithms. Establish a common metric, posing questions such as will it raytrace this? and How long will it take to raytrace this?. Formulate an approach for achieving the objective and complete Phase I by delivering a report describing the results of the above.

PHASE II: Implementation of the Phase I results to develop a prototype ray tracing tool. Algorithms will be implemented by either the creation of new code or the proper usage of existing code that meets specifications. Once implemented, each algorithm will be subjected to a rigorous test and evaluation suite. Once assembled, the overall ray trace tool will be subjected to the evaluation methodology developed in Phase I. The overall goals are: 1) Distribution of the rendering problem over more than 100 CPUs (dissimilar manufacturer running UNIX) with a minimum efficiency of 98%, 2) Rendering of a 10 kilometer X 10 kilometer terrain with approximately 50,000 trees, 100 high resolution vehicles, and 5,000 detail items (such as 'houses, roads, fences, telephone poles), and 3) Rendering the above images 'at 640X480X24 bits (full color) at 5 hertz. The entire model will contain 'approximately 20,000,000 solids.

POTENTIAL COMMERCIAL MARKET: The potential commercial market for this real time ray tracing software is anyone that requires much higher detailed computer generated imagery of complex geometric models than is currently available. These fields include film making, scientific visualization, FAA studies, motion simulators (ground and air), construction planning, interior design, and antenna placement.

A95-039TITLE:Super High Frequency (SHF) Tri-Band (C.Ku. and X) Antenna Feed for Satellite Communications Terminal

CATEGORY: Engineering Development

OBJECTIVE: Develop and demonstrate a new and innovative approach for Multi- band Satellite antenna feed systems. The feed system to be developed will cover the commercial Satellite Communications Bands C and Ku. as well as the military DSCS X-Band.

DESCRIPTION: The trend in the military is to utilize commercial Satellite Communications (Satcom) to augment military Satcom. Current systems utilize three or more separate feeds to that would be physically connected to the antenna, one at a time, for this application. A tri-band feed would allow the user to change from one satellite frequency to another without a manual change to the antenna configuration. This tri-band feed would also be expected to reduce the weight of the system. The weight is important to tactical systems which have severe weight restrictions due to the host vehicle.

PHASE I: Investigate new and innovative methods for combining the three frequencies onto a one feed system. Modeling and analytical evaluation shall be used to predict the performance of the feed across all frequency bands. Mechanical analysis shall be performed to determine the raggedness of the feed system in a tactical environment.

PHASE II: The concepts developed in Phase I shall be implemented into an engineering design and prototype development. The Feed shall be tested on an antenna chosen by the contractor. Detailed design drawings and specifications shall be developed.

POTENTIAL COMMERCIAL MARKET: The technology developed would have direct application to the commercial Satcom market. Two of the three frequency used are commercial Satcom frequencies. Weight savings for commercial Satcom is an issue as in military Satcom.

A95-040TITLE:Advanced Common Digital Hardware for Intelligence Electronic Warfare (IEW) Systems

CATEGORY: Exploratory Development

OBJECTIVE: Current Communications ESM/ECM systems are required to be high performance which tends to increase costs, both production and operational and support (O&S). In addition the number of systems is relatively small, thus the ability of large scale production to reduce costs is limited. Advantage may be taken of the fact that ESM/ECM systems are essentially totally digital hardware. However presently the systems are composed of multiple types of different digital technology: specialized signal processors; general purpose or fast personal computers; signal analysis workstations; and waveform generators using digital processors. The highly parallel architecture as now used allows consideration of a system composed of common digital processing components for almost all functions. Although common digital processors may be more expensive than any one component now used, the large number, even in low density equipment field applications, of the same component can reduce production costs and O&S costs. These components (as line replaceable items or circuit card assemblies) must be stocked as spares and configuration managed separately. Operational and Support (O&S) costs are driven by the number of different items that must be maintained in the inventory.

DESCRIPTION: The common processor must account for the high data processing speeds needed for high dynamic range, signal acquisition/analysis in milliseconds in dense environments and real time multiple signal ECM response which can also be created digital. This may be accomplished with common processors through the use of innovative algorithms, special application chips, host common, lower performance, processors or a combination of approaches. A significant hardware architecture challenge is the extensiveness of hardware commonality achievable between the signal analysis kinds of functions, the data processing functions, display generation functions, and the jamming control/ waveform synthesizer functions. These functions are at different speeds and have different input output forms of signals (e.g., analog to digital, digital to digital, digital to analog). Objective is to have common components, e.g., microprocessors, DSP chips, et al, which reduces first time costs and some spares cost but a more important objective is to group these common components into as few LRUs, e.g., printed circuit boards, as economically and maintenance possible or these are the stews forming the system and are the major costs in first time fabrications and in O&S costs. This requires the same or very similar PCB's to do signal processing, data processing, and waveform generations through possibly an arrangement of inputs/outputs, data bus protocols to reduce inter connectors, and possibly latent code and connectors, exercised only when needed.

PHASE I: This will be trade-offs of various candidate architectures, simulations of the response of these architectures for performance estimates of resulting cost reductions to be achieved. Key issues are ways to handle both low and high speed functions, input and output translations, data bus and signal path optimization and producibility/costs per processor/function. Driving point functions and their sensitivity must be identified. A final technical report will describe in detail the results.

PHASE II: A single real time operating breadboard thread of the selected architecture and components will be assembled to verify performance and better refine costs reduction estimates. The deliverables would be the architectural design of a system based on the breadboard and a final technical report.

POTENTIAL COMMERCIAL MARKET: The DSP architectures and hardware developed for this project will have a very large number of multidimensional processing problem applications in data processing, imaging and medical instrumentation. In addition this concept has application to radio transceivers of all types, including satellite communications and radio data handling networks.

A95-041TITLE:Synthetic Aperture Techniques for Radar Resolution Enhancement

CATEGORY: Exploratory Development

OBJECTIVE: A millimeterwave radar is currently being developed by the Army to provide the tank commander with an all-weather target acquisition capability. A radar sensor is needed to penetrate atmospheric obscurants such as rain, fog and smoke that limit the performance of Electro-optics and Infrared sensors. Synthetic Aperture techniques are generally well understood by the radar community but these techniques are not currently being employed in low-cost designs. The objective of this research project is to investigate the use of affordable Synthetic Aperture Radar (SAR) and inverse Synthetic Aperture Radar (ISAR) techniques to improve stationary and moving target classification and fire control performance.

DESCRIPTION: The approach of the current development program is to demonstrate an affordable Moving Target Indication (MTI) radar. The MTI radar will function as a target acquisition sensor and will hand off target detections to the FLIR sensor for accurate fire control. A Ka-band (35 GHz) solution was selected for the following reasons. Milliter wave-length radar is required to keep the size of the antenna aperture reasonably small. Within the millimeter wavelengths, atmospheric absorption limits detection range outside of the Ka and W frequency bands. Ka band has superior range performance in conditions of moderate to heavy rain. The antenna being used for the brassboard demonstration program is a one foot diameter parabolic reflector. The beamwidth is approximately three degrees. The resolution of a real aperture radar of this type limits performance with respect to fire control accuracy and target-to-clutter ratio for stationary target detection. A radar capable of performing fire control and stationary target detection will require enhanced angular resolution. Affordable SAR techniques are needed to provide the tank commander with an all-weather STI and fire control sensor.

PHASE I: The first phase will consist of requirements definition, system specification and trade-off studies. The contractor shall conduct a requirements definition study. This study will include an analysis of user requirements and subsequently allocate user requirements to specifications for a SAR upgrade to MGR. Using the SAR specification as a reference, the contractor shall review the design of the MGR and develop and define the hardware and algorithm architecture needed to perform low cost SAR processing. Trade studies shall be conducted to determine the optimal approach with respect to cost and performance. SAR techniques shall be used to increase the resolution of the radar sensor when the radar platform is in motion. ISAR techniques shall be employed to image the target when the target is in motion.

PHASE II: This phase will consist of data collection, algorithm development and a non-real time demonstration of the SAR algorithms. The contractor shall fabricate any data collection hardware needed to interface with the MGR and develop waveforms for the MGR. The contractor shall conduct data collection with the MGR and use the collected data to optimize the SAR algorithms and perform a laboratory demonstration of the low-cost SAR techniques. The contractor shall procure commercial-off-the-shelf signal processing hardware and software development tools for the non-real time demonstration of the SAR techniques. A phase three program will result in a real-time demonstration of low-cost SAR techniques. The low-cost, lightweight techniques developed throughout all phases of this SBIR can be readily extended to other platforms such as UAVs', aircraft and spacecraft.

POTENTIAL COMMERCIAL MARKET: Low-cost techniques for implementation of SAR and ISAR can be used in commercial radars to support applications such as weather observation, topographic mapping and survey. SAR radars are commonly used for surveying, construction of highways and mineral exploration.

A95-042TITLE:Blind Channel Estimation via Per-Survivor Processing Techniques

CATEGORY: Exploratory Development

OBJECTIVE: To investigate, develop, and demonstrate blind channel estimation and acquisition methods for digital communications signals that are based on so-called Per-Survivor Processing techniques.

DESCRIPTION: Traditional design methods for digital systems operating over a noisy and dispersive communications channel usually employ an adaptive equalizer for channel estimation and acquisition. The receiver uses data-aided

techniques to form an estimate of the inverse response of the channel, such that, the cascade of the total channel with the equalizer is a flat, all-pass transfer function. Blind acquisition refers to accomplishing the estimation and acquisition process without the benefit of a training sequence. Per-Survivor Processing (PSP) affords a general framework for approximating an optimum Maximum Likelihood Sequence Estimation receiver in an uncertain environment, such as an unknown intersymbol interference (ISI) channel. PSP provides a method of estimating unknown parameters within the structure of a Viterbi algorithm. The data sequence associated to each survivor in the Viterbi processor is used as data-aiding sequence for the "per-survivor" estimation of the unknown parameter. This research will attempt to use these PSP techniques in the development of blind forward channel estimation methods.

PHASE I: Investigate theoretical approaches, for blind PSP channel estimation/ acquisition, develop and simulate promising methods and techniques, evaluate and compare the performance of PSP-based techniques versus established blind acquisition methods, and document the approach, design, and performance results in a Phase I report.

PHASE II: Implement and demonstrate computationally efficient techniques on appropriate commercially available processing hardware (6u VME DSP or vector/ array processors) to illustrate the operational feasibility and functionality of the algorithms in a realistic signal environment. The result of Phase II will be a demonstration prototype that employs PSP-based techniques for blind channel estimation and acquisition of digital communications signals such as M-ary PSK and Quadrature Amplitude Modulation.

POTENTIAL COMMERCIAL MARKET: This technology would have tremendous application in the commercial communications market. Communications systems and networks employing digital signaling schemes would all benefit from these techniques. Mobile communications systems, such as digital cellular phones and fax/modems, and the emerging Personal Communication Systems/Networks are just some of the potential commercial markets in the communications industry.

A95-043TITLE:Innovative Battlefield Visualization Techniques

CATEGORY: Exploratory Development

OBJECTIVE: To develop innovative techniques and methods to assist in the display of battlefield data and information to the commander. For example, a weather map is the most complete and expedient method to convey current and future weather patterns. This portrayal is readily understandable to any level of expertise. The objective of this effort will be to project battlefield information in this manner, such that rapid and effective decisions can be made by the commander.

DESCRIPTION: The basic requirement for presenting battlefield data and information is a map with accompanying overlays. Much time is wasted waiting for this information to be processed. Time is also wasted if it is presented in a manner that is not readily understood. The two most important presentations are the Intelligence Preparation of the Battlefield (IPB) and the daily Intelligence Summary (INTSUM). This effort is to focus on innovative techniques and methods to both generate and display information of critical importance to the Battlefield commander.

The innovative processing techniques can be focused in one or more of several areas. One of these areas include issues relating to data presentation and how humans perceive information. There are a multitude of methods for displaying different types of information. For example, quantitative data may be expressed as icons that automatically change according to the value represented. Using the weather analogy, temperature can be expressed using a standard thermometer icon, whereby the mercury rises and falls in an animated fashion. In many of these cases, the psychology of the person to which the data is being presented must be taken into account if the data is to be properly absorbed.

The second area to consider involves computational issues related to increasing the speed and resolution of map, terrain, and overlay generation. Currently, the processing of battlefield information is time intensive and laborious. This is sufficient for pre-deployment contingency planning, but not in a fast paced battle envisioned by Air Land Operations. For example, there are gigabytes of terrain data that must be searched and processed with incoming battlefield information. In order to accurately present this battlefield information, enormous processing power would be required in a tactical environment. This issue is a trade-off between resolution and computational efficiency.

Lastly, considerations must be made to issues related to data acquisition, storage and dissemination. An immense amount of data must flow across the battlefield if a common view is to be achieved at all echelons. The

importance of this is to perpetuate common goals and objectives amongst battlefield elements. For example, a Battalion Commander should have the same data to support his view of the battlefield, that is a subset of its parent Brigade. Likewise, the Brigade Commander's picture of the battlefield should consist of an exact subset of its parent Division. This will require large amounts of battlefield information be communicated across these elements in a distributed fashion. When combined, the use of these techniques designed to solve the above issues, should lead to sophisticated multimedia presentations. The optimal goal is to give battlefield commanders the capability to perceive battlefield activities from the eyes of their troops.

PHASE I: Explore and develop innovative techniques for presenting battlefield information to the commander. Exploration should consider the media as well as the methodology to be used. Specific topics to be considered are as follows:

a. Not all information will be kept locally with the intelligence producer. This would require that his local database interact with external databases that contain the data that is needed. The local database should be smart enough to know where and how to get and retrieve the information.

b. Once the data is retrieved, it must be processed and displayed in a readily understandable fashion. This may require the development of an updated Army symbology to include new symbols such as the animated icons, stated above. This may also require the development of overlays such that the 3-dimensional battle can be envisioned.

c. The intelligence producer must then readily illustrate the resultant products to the commander. Rather than providing it in a hard copy fashion, the information may be transmitted to the commander's screen. The briefer could present his information electronically, utilizing teleconferencing techniques.

The final product should be a proof of principle demonstration.

PHASE II: Formalize and extend the concepts developed during Phase I into a Battlefield Visualization Server. The server will be adapted to create readily understandable IPB products and graphic INTSUMs. The software should be robust enough to support tactical Intelligence Analysts in a field exercise.

POTENTIAL COMMERCIAL MARKET: The development of new and innovative data representation, presentation, and storage and retrieval techniques has widespread application. Areas of immediate use include disaster preparedness (similar to a fusion problem), search and rescue, aircraft simulations, and civil engineering and environmental data presentation. As an example, cars of the future will have maps that will overlay roadway situations (e.g., construction, areas of high traffic). There is not enough time for the driver to absorb all of the information on the display and be able to concentrate on the road much less react.

A95-044TITLE:Display of Sensor Data on Mapping on Army Command and Control System (ACCS) Hardware

CATEGORY: Exploratory Development

OBJECTIVE: The project will involve solving the problem of UTM "corners" which has presented a difficulty in interactive mapping. When the area being mapped is near a UTM corner, it is difficult to use existing database techniques to manipulate the UTM input to assure the information appears on the proper map since at a corner the maps are not square but take on irregular shapes. The solution to this problem will need to be an innovative one and will, when accomplished, provide for cross-applications to other military and commercial systems.

DESCRIPTION: The effort will include display of IREMBASS message information on standard UTM maps using the ACCS Portable Computer. The database of the mapping information will be tailored under this effort to account for the UTM "CORNER EFFECT". when the area being mapped is near a UTM corner, it is difficult to use existing database techniques to manipulate the UTM input to assure the information appears on the proper map since at a corner the maps are not square but take on irregular shapes. The IREMBASS messages are output in modified ASCII format via the RS-232C port on the Monitor-Programmer and in turn allows the user to create sketch maps. The use of the UTM maps will eliminate the need to create topographic information and at the same time locate the UTM coordinates of the sensors so that more accurate targeting/locating data can be generated. The effort is unclassified IAW the IREMBASS Security Classification Guide for this type of effort.

PHASE I: Phase I will involve using the existing Advanced Monitoring System Display software and porting it onto the ACCS Portable Computer including porting of existing Army UTM maps. Phase I will require the software to be programmed in Ada and solve considerations such as memory requirements, timing, message processing and

display. UTM mapping of boundary lines (including corners), and interactive display of messages on the mapping data.

PHASE II: Phase II will document the software design and test the product to assure usability. The design from Phase I will be subjected to field usage and inhouse testing to validate the maturity of the design from Phase I. Any deficiencies or operational enhancements for user friendliness will be made during Phase II.

POTENTIAL COMMERCIAL MARKET: Since the ACCS POrtable Computer is a commercial standard and many commercial markets exist for sensor applications (industry and home security), the mapping display of sensor messages will allow any small business to market the mapping function commercially. The government has a need for enhanced interactive display of sensor information for the fielded IREMBASS system on a UTM mapping background and will need to solve the UTM "corner" problem to allow world-wide usage.

A95-045TITLE:Lightweight Monolithic Opto-mechanical Assemblies for Infrared Seekers

CATEGORY: Exploratory Development

OBJECTIVE: To develop lightweight athermalized monolithic optical/mechanical assemblies for use in the sensor portion of advanced infrared seekers.

DESCRIPTION: Recent advances in the development of lightweight materials which possess high strength, are dimensionally stable over wide temperature ranges, and can be machined to optical tolerances offers the potential to reduce the complexity and cost of future infrared seekers systems and other electro-optical systems for military applications. This research activity seeks the development and perfection of design techniques utilizing these advanced materials in the areas of an integrated/monolithic telescope, its supporting structure, and gimbal functions for line of sight pointing and stabilization. This effort should result in the demonstration of an advanced seekers design which offers significant overall weight reduction; high optical and dimensional stability; passive athermalization over wide temperature ranges; precision line of sight control under stressing dynamic vibrational environments; and low cost rapid fabrication using CAD/CAM manufacturing. Multi band (i.e., visible, infrared) and multi mode (passive, active) operation is also considered desirable. Both advanced materials and design techniques are sought to meet the goals of this task.

PHASE I: An advanced lightweight, athermalized optomechanical seekers assembly shall be conceptually designed and analyzed to demonstrate high precision optical and mechanical performance over stressing environmental conditions. Hardware demonstrations of key component designs is desired to assess technical feasibility.

PHASE II: Design, fabricate, and test an advanced integrated monolithic seekers opto mechanical assembly including the optical telescope, supporting structure, gimbal and pointing/stabilization control subsystems. The prototype seekers hardware shall be capable of being integrated with an existing advanced FPA/ dewar/cryogenic assembly. Qualification type tests shall be performed to assess overall optical and LOS control performance.

POTENTIAL COMMERCIAL MARKET: Technology is applicable to the reduction of complexity, weight, and cost of all commercial electro-optical systems. Examples include producing miniature motors, shutters, and a vast number of electro-topical systems. These are used in all high-tech optical applications.

A95-046TITLE:Development of Smart Structure with Embedded Optical Fiber

CATEGORY: Exploratory Development

OBJECTIVE: Develop technique to embed optical fiber in a composite material in much a manner that the integrity of the optical fiber will be preserved and the tensile strength of the composite material will not be degrated. Develop composite structure with embedded polarization-maintaining (PM) optical fiber.

DESCRIPTION: A technique or method is needed to successfully embed PM optical fiber in composite material. Curing the embedded composite structure without degrading the embedded optical fiber is a crucial step in the embedding process. Generally, the embedded composite structure should be cured at a high temperature for a sufficient

amount of time to preserve or increase tensile strength of the composite structure. The Inertial Systems Branch of the Guidance and Control Directorate is presently conducting an applied research program investigating an interferometric fiber sensor utilizing PM optical fiber to measure bending and twist in an aluminum rod. However, ultimately the fiber optic strain sensor will be embedded in a composite material for a smart structures approach.

PHASE I: First place objective for proposed task is to survey various composite materials that will be suitable for embedding Fujikura PANDA PM optical fiber. This will include evaluating the coefficient of thermal expansion (CTE) for closeness to that of glass and curing specifications for each possible composite candidate. Evaluation of curing methods must be based on maintaining the integrity of the fragile PM fiber and the tensile strength of the cured, embedded composite structure. Strength of the composite structure will be critical since the embedded composite rod will have to withstand bending and twist, and then return to its original state. Examine methods for protecting optical fiber leads exiting composite materials. Provide detailed analysis of all feasible materials and recommend specific composite material. Propose technique of embedding PM fiber into composite material in a rod form.

PHASE II: Second phase objective for proposed task is to develop and demonstrate the technique for embedding optical fiber into a composite material. Perform testing to evaluate tensile or shear strength of embedded composite structure. Analyze integrity or optical performance of embedded optical fiber. Provide detailed procedure description, including a description of all necessary equipment, materials, and facilities, required to produce and demonstrate the embedding technique. Provide test data.

POTENTIAL COMMERCIAL MARKET: The market for strain sensors has grown rapidly in the past few years. There are numerous commercial applications for fiber strain sensors such as earthquake indicators, materials processing (cure) monitors, and structural monitors for bridges, roads and building.

A95-047TITLE:Landmark Recognition for Robotic Ground Vehicles Using Biologically Based Artificial Intelligence Approaches

CATEGORY: Exploratory Development

OBJECTIVE: This task will explore and develop qualitative and biological artificial intelligence approaches to landmark recognition and place determination utilizing image-based object recognition techniques. Algorithms will be developed to perform recognition of ground based navigational aids such as water, towers, bridges, railroad tracks and distinctive natural terrain features for outdoor robotic applications. Object recognition of indoor objects will include chairs, tables, boxes, walls and door ways. These recognized landmarks will be correlated to vector based digital map data and will demonstrate the ability to perform ground based navigation applicable to unmanned robotic ground vehicles.

DESCRIPTION: This task will develop and evaluate qualitative based methods for landmark recognition and investigate biologically driven artificial intelligence approaches to location determination based on visual cues. Robotic vehicles (indoor and outdoor) in the future will require the ability to recognize locations based on visual surroundings. Vectored map data can provide some insight into the surrounding environment along with global position satellite information. This data alone however will never be complete enough for all robotic navigation exercises, especially in cases where previously planned navigation routes can not be completed. In an indoor application, a bridge out or a bomb cratered road may prohibit the original robotic plan from being completed. In an outdoor application, re-arranging an office or stacking some empty boxes in the hall could destroy a robots' ability to navigate without adaptive capabilities. Object recognition will be required for localized navigation and dynamic route re-planning and adjustment in each of these cases. Military applications for this technology include target reconnaissance using unmanned ground vehicles and automated re-supply vehicles. Commercial applications include automated robotic food delivery for hospitals, robotic mail delivery for office buildings and automated map making.

PHASE I: The first phase will involve developing qualitative artificial intelligence approaches that can be applied to location recognition and landmark determination. The more involved and mature methods that exhibit invariance to rotation, scale and translational effects will then be implemented and tested against a global set of indoor and outdoor landmarks. Results of this phase will be in the probability of correct object classification and an indication of the sensitivity to changes in object perspective.

PHASE II: This phase will involve the development of a software test bed that will serve as an evaluation tool for the approaches developed in Phase I. The software testbed will be adapted to include dynamic route re-planning utilizing available vectored map data and shall incorporate a user interface that allows initial route planning and purposeful obstacle placement that can interfere with the original route that was planned. Data collection of landmark image data and associated vectored map data will address both indoor and outdoor robotic applications. The collected data incorporated into the software testbed will demonstrate landmark recognition and location determination for each of the approaches developed in Phase I. Results of this phase will be a software testbed that demonstrates unmanned robotic vehicles navigation utilizing landmark recognition for guidance.

POTENTIAL COMMERCIAL MARKET: The software testbed developed under this effort represents a product that can be adapted for several specific commercial developments. Commercial applications for indoor vehicle navigation include automated robotic food delivery for hospitals and robotic mail delivery for office buildings. Outdoor robotic commercial applications include inspection of hazardous waste storage facilities and automated map making for environmentally contaminated areas. The testbed product develop by this effort will serve as a design tool to prove out the capabilities in each of these commercial applications.

A95-048TITLE:Super Efficient X-ray Generator

CATEGORY: Exploratory Development

OBJECTIVE: Develop high-efficiency x-ray sources whose per cent of total output x-ray energy to electron energy is much greater over what is now in practice.

DESCRIPTION: Electronic generation of x-rays is done by bombarding a target material, such as tungsten, with electrons of high energy, resulting in Bremstrahlung and characteristics x-rays. Energy conversion (electron energy to x-ray energy) ranges from less than one per cent to about three per cent, depending on the kinetic energy of the bombarding electrons. The rest of the energy is dissipated as heat and must be disposed of. This solicitation is for development of high efficient, high flux x-ray sources whose per cent of total output x-ray energy to electron energy is much greater over what is now in practice. The source or sources must not emit x-rays continuously as nuclear sources do, but rather should be switchable (on and off) in a manner similar to electronic sources.

PHASE I: Create and deliver designs for the super efficient high x-ray flux sources. Demonstrate that the designs will meet the requirements, preferably by building a simple prototype tube or a laboratory demonstration. Obtain promise of funding commitment for potential Phase III effort.

PHASE II: Develop, construct, test and deliver one or more working prototype sources.

POTENTIAL COMMERCIAL MARKET: Super efficient x-ray sources have a ready market replacing existing x-ray sources. Super efficient x-ray sources should be smaller, require less cooling, and have higher output flux. These attributes will increase uses for the x-ray device. Commercial markets include all radiographic or x-ray tomographic applications, i.e., non destructive industrial radiography, medical diagnosis, baggage inspection, and integrated chip manufacture.

Cost Reduction: Efficient x-ray sources will be less expensive to operate and more versatile for use. Increased efficiency and high flux density will result in high throughput. This will result in making the x-ray inspection process able to keep up with high volume production. It will decrease the number of inspection systems required for high volume production.

A95-049TITLE:Real-Time Multi-Spectral Burning Residue in Cannon Sensor

CATEGORY: Exploratory Development

OBJECTIVE: Develop a sensor to detect the presence of burning residue in gun chambers quick enough to warn against loading of munitions during rapid fire.

DESCRIPTION: Occasionally, when using combustible cartridge cases for firing cannons, burning embers or residue remains in the chamber. This condition must be detected and the operator warned not to load the next shell. Spectral measurements have been made to characterize the burning combustible case using Inframetrics 760 and Cohu video images of live-fire residue. The thermo-chemical compositions of burning residue gases with their associated radiances has been computed. Search and tracking of target residue entrained in the bore evacuator flow field prior to start of the loading ram is required.

PHASE I: Using off-the-shelf digital signal processing technology, focal plane arrays, appropriately filtered optics and the spectral measurements of burning combustible case, design and build a real- time, multi-spectral (near to MWIR), sensor capable of collecting and processing radiometrically calibrated spectral data for each pixel in an image at video rates. Demonstrate feasibility.

PHASE II: Extend the concept in time, space and spectral extent. Selection of off-shelf electro-optical devices, the fabrication of hybrid or monolithic focal plane arrays, specialized development of extant algorithms for data fusion, and to minimize/eliminate false alarm, will proceed from Phase I. The final deliverable concept, which would employ automatic search and track of residue targets, and which may operate in the UV to LWIR, will be demonstrated for auto-loaded systems at an Army test range.

POTENTIAL COMMERCIAL MARKET: Development of this technology will extend the spectral range of microelectronics applications in the areas of non destructive testing and inspection of munitions and armaments manufacturing processes, including remote sensing fire-alarms in process and development tests. In particular, a safe-to- load sensor would be useful in the development of munitions. Army operations, such as artillery and tank cannon user training, will experience more accurate, reliable and safer human and autoloader performance. Civil applications are envisioned in agriculture and earth resource mapping, medical diagnostics, sub-surface object and drug detection, automobile exhaust testing, detection of gases and volatiles, control of chemical vapor deposition processes, and powerplant combustion optimization.

A95-050TITLE:Solid State Angular Rate Sensor

CATEGORY: Exploratory Development

OBJECTIVE: Conceptual design, prototype fabrication and demonstration of a solid state angular rate sensor for precision guided munitions and commercial rate sensing applications.

DESCRIPTION: The current techniques for measuring the rotation rate of various types of conventional and precision munitions include active and passive radiometry, mechanical rate gyros and Yaw Sonde methods. These techniques, while very effective, are relatively complex and expensive to implement in projectiles in production quantities. It would be highly desirable to develop a self contained, small size, low cost, rugged all solid state angular roll rate sensor to measure spin rate for use in munitions dispensing projectiles and in autonomous and command guided precision munitions. The sensor device should be compatible with micro device fabrication techniques such as thin film deposition and photo-lithography and, in addition, should be capable of large scale batch fabrication techniques similar to that utilized in the integrated circuit industry. The use of bulky electro-mechanical power dissipation components is undesirable for the device design. The desired goals for the device design are:

* Packaging volume of less than 1.5 cc including processing electronics
* Measure rotation rates up to 300 rev/sec with an accuracy of 0.1%
* Bandwidth greater than 100 Hz
* Consume less than 0.1 Watt of power
* Acceleration hardenable to 20,000 Gs
* Capable of operation throughout the military temperature range of -50 to +140 F.

PHASE I: The contractor will perform a detailed scientific and engineering analysis, including, but not limited to computer simulations and analytical analyses to develop a feasible concept of a solid state angular rate sensor compatible with the design goals specified above.

PHASE II: The contractor will fabricate a breadboard prototype configuration of the angular rate sensor specified in the Phase I design and will demonstrate the operation of the device concept.

POTENTIAL COMMERCIAL MARKET: The successful development of this device will provide a low cost, low power, mechanically rugged angular rate sensing capability for aerospace, transportation and manufacturing, such as robotic control, drilling operations, rotating machinery operations and vehicular transportation systems.

A95-051TITLE:Active Suspension Control Using Preview Information

CATEGORY: Exploratory Development

OBJECTIVE: To enhance active suspension vehicle mobility and ride comfort by incorporating sensor preview information into the control of the suspension system.

DESCRIPTION: Vehicles with active suspension systems have been/are being developed under past/current TARDEC programs. Preview sensor technology programs are also underway. New active suspension control algorithms must be developed to utilize the terrain profile information obtained from the preview system. Vehicle speed and orientation will be essential when considering the preview data. This look ahead capability should improve cross-country ride performance and vehicle mobility.

PHASE I: For phase I of this program the input data requirements for a preview active suspension control strategy should be investigated and identified. A general preview control strategy would be developed and demonstrated with a computer simulation.

PHASE II: For phase II of this program a preview active suspension control algorithm will be developed, installed, and demonstrated for a specific active suspension vehicle system that provides preview sensor information. The details of the active suspension hardware and the preview sensor package will be provided by TARDEC at the end of Phase I.

POTENTIAL COMMERCIAL MARKET: Preview control technology could be a benefit to auto industries, robotics, and autonomous vehicle research.

A95-052TITLE:Embedded Sensors and Control Mechanisms for Military Tactical Bridging Program

CATEGORY: Exploratory Development

OBJECTIVE: To explore the applicability of the wide variety of microsensors and microactuators, which now exist, for incorporation into our Military Bridging Advanced Technology program. For example, the goal of employing embedded sensors and related control mechanisms on bridge structural components for heath monitoring and other purposes.

DESCRIPTION: Embedded sensors have already gained wide use within the aerospace and automotive industries. Microsensors have evolved from the microtechnology field which is already estimated by industry analysts to be in excess of one billion dollars annually. Some recent studies have predicted that the world market for micromechanical devices will reach eight billion dollars by the year 2000. This effort will 1) assess the current state-of-the-art in this field to compile a database of existing microsensor and microactuator platforms now being developed in the industrial, government and academic communities, 2) evaluate their potential for application to existing and future tactical military bridging assets and 3) select and test applicable sensor/actuator platforms on existing bridging assets, in both laboratory and field environments, to evaluate their role in current and future military bridge design and production.

PHASE I: The contractor will survey the field to assess the availability of existing microsensor and microactuator platforms and develop a computerized data base to show the current state-of-the-art in this field.

PHASE II: The contractor will assess the above data base and select and recommend those platforms that are applicable to the military bridging field. The government will select from this listing those sensors platforms which will be evaluated under controlled laboratory conditions on selected bridging structural components using existing load frame equipment. The government will down-select those microsensor/microactuator platforms to be included in a follow-on field test and evaluation using existing military bridging assets. The contractor would provide the sensor platforms, monitor the field testing effort and provide a final report containing a summary of the test results and recommendations on the design and incorporation of such microtechnology products into future military bridge design and production.

POTENTIAL COMMERCIAL MARKET: This technology assessment effort and results of the testing should be of great interest to those federal and state agencies who have the responsibility for commercial highway bridging design, maintenance and safety inspection.

A95-053TITLE:Hardened Subminiature Telemetry and Sensor System

CATEGORY: Advanced Development

OBJECTIVE: Provide flight data characteristics and internal status of onboard functions of present and future smart munitions. The data will be used for munitions design and as input data for future modeling and simulation efforts.

DESCRIPTION: There are nine technology areas of interest: (1) Antenna: requires high relative dielectric constant to reduce size and coating required to withstand burning propellent; (2) Transmitter: S/L Band; (3) PCM Data Acquisition System: channel and frame programmable with signal conditioning, 2M bps; (4) Accelerometer: 3 axis, greater than 100,000 g's; (5) Gyro: roll, pitch and yaw rates, signal processing on ground, software required; (6) Pressure: 100,000 psi to -100 psi; (7) Temperature: propellent temp, windshield temp; (8) Battery: 100,000 g's; (9) Acoustic Scoring Technology: utilized for projectile and telemetry system calibration. The entire system is restricted to the following physical conditions: (1) Volume: 0.46 cubic inches or less; (2) L/S Band Transmit Frequencies: standard telemetry bandwidths; (3) Launch Pressure: up to 100,000 psi; (4) Launch Temperature: up to 3000 degrees Celsius for 10 ms ; Launch Acceleration: up to 100,000 g's.

PHASE I: Develop feasible designs for one or more of the functional areas described above and propose or demonstrate such design(s).

PHASE II: Develop engineering prototypes suitable for incorporation into existing weapon systems or automotive platforms.

POTENTIAL COMMERCIAL MARKET: The developed sensors are adaptable to the broad automotive industry for use in applications to enhance safety and improve navigation.

A95-054TITLE:Full Flight Video

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate a system capable of following, capturing and recording on video a projectile in flight. Continuous motion of the projectile from the muzzle to final impact must be captured on video tape. System will be exposed to harsh weather/environment.

DESCRIPTION: System will include a radar as a primary controller (driver) that will control multiple pedestals located down range. Pedestals will be controlled through fiber optics and track both azimuth and elevation. Each pedestal will have a high speed video camera and lens that will provide the capability to record high speed projectiles, travelling at velocities ranging from 800 meters to 2000 meters per second. The pedestals should be positioned to ensure a smooth tracking and still maintain sharp image of the projectile. When determining location of the pedestals, other parallel ranges must be considered. Smooth projectile speed information and high image quality will be used to calculate pitch, yaw, and velocity of the projectile. All data will be recorded in real time. The pedestals have to be configured and synchronized such that the resulting video will have no drop outs or dead areas of the trajectory. Time must be annotated to a video tape in order to ensure no time overlap or dropouts during the procedure to obtain a continuous full flight video.

PHASE I: Investigate new and innovative ways to capture, process, save and analyze full flight video measurements. The investigator will obtain all current available information pertinent to this task and determine how to solve the many technical issues associated with the full flight video problem. Phase I should demonstrate that the concept will be able to recover the signal in the event of dropouts. The system must demonstrate that it will work in the existing environment. The investigator shall demonstrate that the system can maintain a live image of the projectile throughout its trajectory and be capable of providing accurate data to calculate pitch, yaw and velocity data.

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

POTENTIAL COMMERCIAL MARKET: The technology required to develop a fielded system is applicable to various gun/ammunition manufacturers, such as small arms and large caliber guns. The high speed video camera has potential for several applications in the commercial video market.

A95-055TITLE:3-D Microwave Imaging System

CATEGORY: Advanced Development

OBJECTIVE: To develop a 3-D "microwave camera" for non-intrusive characterization of materials; the primary objective is to detect liquid flow channels in a porous low-loss dielectric medium.

DESCRIPTION: X-ray, ultrasonic and nuclear magnetic resonance imaging techniques have evolved to a high degree of sophistication and these techniques are widely used for biomedical applications. However, microwave imaging techniques are less developed. The development of sophisticated microwave components and improved signal processing techniques suggest that microwave imaging can also be used for a variety of applications. Some potential applications include biomedical imaging, imaging radar, detection and identification of buried objects, and nondestructive evaluation of composite materials. We are interested in a microwave imaging system to study the physics of fluid flow in a porous medium. A 3-D image of liquid flow patterns in a volume (approximately 0.5 to

1.0m3) of a porous material is required. Our specific interest is to investigate the movement of water along preferred flow paths during snowmelt. An understanding of water percolation through porous media is required for basic research in soil and snow hydrology and radar remote sensing application over a snow-covered terrain. Due to the large dielectric contrast between water and ice at the microwave frequencies and the relatively large sample volume required for our applications, a microwave imaging system appears to be an ideal solution. The system should be able to detect water channels whose diameter ranges from 0.5 to 10.0 cm. To reduce the size of the proposed microwave imaging system, a near-field measurement technique is preferred. An array of detectors is preferred over a scanning system to reduce the measurement time.

PHASE I: Demonstrate understanding of microwave measurement techniques and signal processing and inversion algorithms. Demonstrate basic operating principles through model simulations.

PHASE II: Develop, test and modify (if necessary) a practical prototype system.

POTENTIAL COMMERCIAL MARKET: Microwave meteorology, biomedical imaging, noninvasive detection of defects in materials, detection and identification of buried objects.

References:

1. Caorsi, S., G.L. Gragnani and M. Pastorino (1993) Numerical electromagnetic inverse-scattering solutions for two-dimensional infinite dielectric cylinders buried in a lossy half-space, Microwave Theory and Techniques, vol. 41, pp. 352-356.

2. Lin, D.B. and T. H. Chu (1993) Bistatic frequency-swept microwave imaging: principle, methodology and experimental results, Microwave Theory and Techniques, vol. 41, pp. 855-861.

3. Joachimowicz, N., C. Pichot and J. P. Hugonin (1991) Inverse scattering: An iterative numerical method for electromagnetic imaging, IEEE Transactions on Antennas and Propagation, vol. 39, pp. 1742-1752.

4. Bolomey, J.C., C. Puchot and G. Gaboriaud (1991) Planar microwave camera for biomedical applications: Critical and prospective analysis of reconstruction algorithms, Radio Science, vol. 26, pp. 541-549.

A95-056TITLE:High Energy Laser Plasma Diagnostic Development

CATEGORY: Advanced Development

OBJECTIVE: To develop a suite of high energy laser diagnostic devices to measure plasma parameters.

DESCRIPTION: Hydrogen fluoride/deterium fluoride (HF/DF) chemical high energy lasers (HELs), both pulsed and continuous wave as well as CO2 HELs, typically create large plasmas when interacting with targets. This occurs under a large variety of atmospheric conditions ranging from partial atmospheres of inert gases through fast-flowing STP conditions to high pressure conditions all of which are physically interesting with large commercial potential. Such plasmas can also be created when the laser beam(s) is brought to focus even in the absence of solid targets. The spectral composition, homogeneity, energy distribution, density, and temperature of such plasmas are of primary interest to laser and targets materials developers as well as material scientists and chemists. The ability to time resolve molecule formation in the plasma would be an extraordinarily valuable tool. Knowing such information would allow materials researchers to monitor plasma conditions during materials synthesis processes. Instruments developed should smoothly integrate data acquisition and processing to provide user interfaces suitable for industrial research and process control.

PHASE I: Early efforts should include a study (or review) of existing plasma diagnostics currently utilized in government, academic, and commercial institutions. An effort to analyze and identify critical needs of High Energy Laser Systems Test Facility (HELSTF) materials research customers will also be required. Finally, design of instrumentation and the fabrication of a novel prototype plasma diagnostic should also be a priority in Phase I.

PHASE II: Second phase efforts will attempt a suite of more sophisticated instruments capable of thoroughly analyzing laser plasmas.

POTENTIAL COMMERCIAL MARKET: The commercial market for such diagnostics will prove to be very lucrative. These plasma states are useful in both military and commercial research, including novel material synthesis such as occur during Fullerene formation. Plasma can be used to produce coatings for glasses, contact lenses and other

lenses, and medical implants. Additionally, fusion energy laser/plasma interactions are important to the market potential for related instruments.

A95-057TITLE:Wideband Waveform Generation Using Single Sideband Conversion of a Direct Digital Synthesized Signal

CATEGORY: Advanced Development

OBJECTIVE: Study the limitations on the generation of very wideband chirp signals via single side band (SSB) upconversion of an arbitrary waveform synthesizer output.

DESCRIPTION: Communications and radar applications are increasingly interested in wide bandwidth operation. The millimeter wave (MMW) radar at the Kwajalein Missile Range (KMR) is similarly upgrading to a 2 GHz bandwidth. The goal is to achieve a 50 microsecond, 2 GHz linear frequency modulated chirp with a 0.5 degree RMS phase error and a 4 degree RMS phase jitter pulse-to-pulse. Several techniques are currently under development, but an investigation into using SSB mixers is desired.

PHASE I: Analyze and select a chirp generator design based upon SSB upconversion of an arbitrary waveform generator.

PHASE II: Implement and test a prototype based upon the phase I study. Phase II funding will be dependent upon proving superiority of the SSB approach over techniques currently under development.

POTENTIAL COMMERCIAL MARKET: This project has applications in both the radar and wideband telecommunications industries. The wideband telecommunications industries would include computer networks, hi-volume data communications, and satellite communications. There is a large potential market for any signal processing technique which would make more efficient communications.

A95-058TITLE:Millimeter Precision Using GPS Receivers

CATEGORY: Exploratory Development

OBJECTIVE: Investigate GPS technology and receiver/antenna configurations to achieve millimeter precision measurements.

DESCRIPTION: Precise positional information to the millimeter level is highly desirable in surveying and other fields, and it is now available using commercial GPS receivers. This project investigates various GPS receiver configurations at the Kwajalein Missile Range (KMR) to provide precise real-time surveys of fixed sensor locations. Additionally, innovative configurations of GPS antennas to measure antenna sag and deformation to the millimeter level in real-time are also encouraged.

PHASE I: Investigate GPS technology and KMR to detail a receiver configuration allowing millimeter precision in surveying fixed sensor locations. Propose a scheme to similarly allow millimeter precision in measuring antenna sag and deformation. Provide GDOP information.

PHASE II: Implement and integrate the real-time system.

POTENTIAL COMMERCIAL MARKET: Precise location determination is essential to many commercial and government applications including surveying. Phase II proposals should also include an assessment of the commercial applications and markets. The techniques developed could be used to monitor deformation of large structures, such as bridges. Attitude determination applications may be feasible.

A95-059TITLE:High Resolution Untethered Lightweight Head Mounted Displays

CATEGORY: Exploratory Development

OBJECTIVE: Development of a low-cost, untethered, color head mounted display having at least 1600 x 1280 pixel resolution, a 140 degree field of view (both horizontally and vertically), and capability for high update rate (at least 60Hz) at maximum resolution.

DESCRIPTION: Head mounted displays are typically used for individual systems for virtual reality, telepresence and situational awareness. The weight, field of view required for effective performance, and the optical system are critical. Metrics for assessing the quality of the physical display should include such factors as luminance, contrast ratio, etc. Standard interfaces should be used to accept signals from any standard I/O source.

PHASE I: High performance display devices are being developed which have the potential to provide solutions to many requirements for an HMD. Identify in detail the technology required to meet all requirements of the stated objective, i.e. high resolution, low-weight, wide field of view, high update rate, and low cost, and the availability of the technology.

PHASE II: If the technology is available, in order to demonstrate proof of principal, a working prototype of the HMD should be built.

POTENTIAL COMMERCIAL MARKET: Entertainment Industry, Education

A95-060TITLE:Simulation Model Validation

CATEGORY: Basic Research

OBJECTIVE: Statistically sound approaches to making inference regarding model validation, rather than reliance upon subjective appeal, need to be pursued.

DESCRIPTION: "Substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the node!" (Schlesinger, et al. (1979))* is a workable definition of simulation model validation. A distinction must be drawn between model validation and model verification, which refers largely to freedom from structural and programming errors. It is generally agreed upon that in order to validate a computer simulation model, empirical observations are necessary and statistical tests are desirable. Beyond this statement of accord, little substantive work has been accomplished. Omnibus methods for simulation validation do not exist and most approaches are problem dependent. Statistically sound approaches to making inference regarding model validation, rather than reliance upon subjective appeal, need to be pursued. * Schlesinger, S., et al., "Terminology for Model Credibility," Simulaiton, 32 (3), 103-104 (1979).

PHASE I: Nonparametric multivariate statistical procedures appear to have a contribution to make. Validation of certain classes of simulation models may not lend itself to quantification by a metric. It may be more appropriate that a simulation model be determined to be "highly representative" or an "adequate representation" or perhaps un "unreliable representation" of the phenomenon it purports to emulate. Fuzzy set theory may have utility as a modeling tool int his context. These, and other relevant technologies, need to be pursued for applicability to simulation validation.

PHASE II: Pending successful completion of Phase I, consideration of simulation validation in the situation where empirical data are not available should be undertaken. This is an unexplored topic, and no guidance on how to proceed exists. New genres of simulation models -- models whose output is highly graphical, and are more animation than quantitative representations -- are being developed. It is unclear what model validation means in this situation but the need to validate remains invariant.

POTENTIAL COMMERCIAL MARKET: Procedures for simulation model validation that are not problem specific are inherently valuable to developers of commercial simulation software since it would provide a means by which the authenticity of their product might be established.

A95-061TITLE:Natural Language Software

CATEGORY: Basic Research

OBJECTIVE: To develop embeddable natural language processing software.

DESCRIPTION: Required is software written in ANSI C code runnable on UNIX platforms including the Sun SPARC or SGI workstations that will include and conform to the following descriptions and constraints.
1. A wide natural language coverage grammar and lexicon preferably a Head-Drive Phrase Structure Grammar as described in Carl Pollard & Ivan A. Sag, Head-Driven Phrase Structure Grammar, CSLI, 1994.
2. This system should include a high level language to be used by linguists for enhancing or modifying the supplied grammar and lexicon. This tool should conform to and take advantage of recent work in unification grammar.
3. The runnable system should take word strings as input and deliver at least the following outputs as required by users: fully or partially annotated parse trees, logical forms, discourse representation structures as describe in Hans Kamp & Uwe Reyle, From Discourse to Logic, Lkuwer, 1993. These structures must also be displayable in some user friendly manner, e.g., drawn two dimensional parse trees.
4. All source code must be available to Government researchers, developers, and programmers. Standards of good modular programming should be used so that any part of the system can be easily modified by knowledgeable people.
5. Users should be able to choose among a variety of state of the art parsers, as well as modify or add other parsers.
6. The following intended uses of this software should be emphasized:
    a. creation of natural language interfaces to automated systems including but not limited to map based decision aids, virtual reality systems, and machine translation systems.
    b. a tool for researches in natural language understanding, machine translation, and natural language generation.
7. The natural language processor should be modularized permitting subroutine calls that pass word strings, syntactic structures, logical forms, discourse structures, and full lexical entries, among others. In addition, it is anticipated that code will be modified by users to permit other data structures to be passed to and from the embedding environment.
Natural language software that is fully embeddable, that we can easily modify for both researcher demonstrations and HCI applications would be very useful to Government and commercial developers of a wide variety of natural language applications. For this purpose this software should look and feel very much like and perform very much like the widely accepted (though developing) HPSG and unification grammars. We also welcome proposed enhancements to the above specifications, including, for example, a similarly embeddable theorem prover.

PHASE I: Conduct a thorough study of the current state of the art in the above items of interest, determine what technologies and software are available for use as is or as modified. Specify and recommend the final product to be developed in phase II. Develop prototype software system for demonstration and government evaluation. Throughout phase I there will be consultation with designated Government people.

PHASE II: Complete software development, preferably in stages. Demonstration of performance on Government platforms by contractor people working with government people, documentation appropriate to above mentioned applications.

POTENTIAL COMMERCIAL MARKET: Superior. Dual-use technology applications include machine translation, hands free/eyes free human computer interaction, telephonic input/output, as well as a development tool for OEMs.

A95-062TITLE:Network Simulation of Technical Architecture

CATEGORY: Exploratory Development

OBJECTIVE: Develop a network modeling capability to simulate a battle command technical architecture to guide the definition, design, and development of the Army battle command systems.

DESCRIPTION: Fundamental to the Army's goal of establishing Force XXI is an imperative need for the Army to maintain interoperability across multiple telecommunications and information systems. The aggregate of these systems

is the Army Battle Command System (ABCS). In order to set up a network that allows interoperable communications among users on the same or different command levels, a viable architecture is necessary. This architecture must be used to design, develop, and test systems in the context of the architecture. Simulation of the architecture and systems operating in the context of the architecture is a cost effective way of evaluating performance characteristics of the architecture. The Army needs a tool that can assist in designing a technical architecture to guide the definition, design, and development of the Army battle command information transport. To achieve the goal, interoperability and flexibility are required to build a battle information infrastructure across all battle command systems, The information transport will support seamless communications for all users on battlefield, within and among the tactical, strategic, and sustaining base environment, and commercial sector. The tool will help integrate various technologies including tactical multiple gateways, commercial standards and technologies (e.g. ATM/SONET, ISDN), high capacity local area networks, personal communications systems, small satellite platforms and ground terminals, direct broadcast satellite technology, interactive multimedia, video teleconferencing, wideband, and mobile. The tool will be used with defined sets of performance requirements and constraints to simulate an infrastructure that is flexible (facilitate force structure planning and dynamic reconfiguration), interoperable, and cost effective by taking advantages of commercial information technologies through adherence and use of open standards, protocols and products, and state-of-the-art telecommunications. There is a strong desire for the tool to have a pathway into hardware description languages, such as the VHSTC for development of hardware meeting the architecture requirements. This tool should have the capability of assisting in the hardware/software co-design problem.

PHASE I: A design of the tool will be performed. Feasibility will be studied and proved by creating a small prototype.

PHASE II: The tool will be constructed, evaluated, and demonstrated. The tool will be readied for market and tested by potential users. Architecture simulations will be demonstrated.

POTENTIAL COMMERCIAL MARKET: Architecture design is a problem common to both the military and commercial telecommunications systems. This tool will be useful to any commercial endeavor which installs multi-site networks for communications, information processing, and other applications. Large companies with nationwide or international networks will benefit by being able to circulate complex networks before committing the networks to hardware and software solutions.

A95-063TITLE:Automated Reusable Software Component Search and Retrieval

CATEGORY: Basic Research

OBJECTIVE: To develop an automated method for searching a reuse repository and retrieving reusable components using algebraic specifications.

DESCRIPTION: Research is solicited on the problem of specification-based software component search. This research should make use of specifications written in the OBJ3 language for both queries and keys. It should base its results in a rigorous way on the mathematical theory of algebraic specifications. It should also address practical algorithms for retrieval of reusable components from software base.

PHASE I: Efforts should focus on development of a formal model for automating the search for and retrieval of candidate reusable software components from a reuse repository. The model should formalize automated search and retrieval methods that use algebraic specifications for identifying candidate reusable components in a real-time software component repository.

PHASE II: Efforts should focus on development of algorithms for intelligent retrieval of reusable software components from a reuse repository using the methods developed in Phase I. This phase should produce a prototype search and retrieval tool based on the methods and algorithms developed in Phase I and Phase II.

POTENTIAL COMMERCIAL MARKET: This technology is applicable to all software evolution activities.

A95-064TITLE:Artificial Intelligence and Visual Techniques for Course Of Action (COA) Development and Analysis

CATEGORY: Exploratory Development

OBJECTIVE: To demonstrate application of AI and advanced visual technologies for COA development and analysis to enhance Commander's decision support capabilities.

DESCRIPTION: Tactical decision making process involves commander and staff estimate of the situation to develop and analyze COAs to select the best COA for the mission. The process starts with the review of the OPPLAN and the mission analysis, leading to COA development and analysis of the possible alternates. The objective here is to assist the commander to develop and visualize, arrayed forces, action reaction sequence with respect to possible enemy movements (Enemy COA), and develop synchronization matrix for the Commander selected COA. Generic architecture will be developed to support BN, BDE, DIV Commanders.

PHASE I: The goal of Phase I is to select appropriate knowledge representation scheme and architecture to represent COA objects including terrain objects of the OPPLAN to support visualization of "action /reaction" dynamics.

PHASE II: 1. Limited visual demonstration of Commander's interactions to control battle outcome of alternate COAs, 2. Support for COA analysis and generation of synchronization matrix. It would be required to model attrition, Personnel /logistic projections to visualize unit combat effectiveness as the battle unfolds. The display will include Commanders interaction points to visualize action reaction animation. The demonstration prototype will serve as the foundation for the creation of a fully functional COA analyzer for the commander and the staff in Phase 3.

POTENTIAL COMMERCIAL MARKET: The commercial application of the developed planning/monitoring (Synchronization matrix)/replanning capabilities are directly transferable to commercial manufacturing applications for planning and scheduling in industrial plant complex. It will provide a powerful decision-making tool for industry and manufacturing.

A95-065TITLE:Modeling Correlation Technology

CATEGORY: Exploratory Development

OBJECTIVE: Provide methods and appropriate automated support that will facilitate the correlation of the different modeling approaches used in the development of requirements for software intensive systems.

DESCRIPTION: Requirements for software intensive systems come from a variety of sources (stakeholders), each representing a view of the system. These views overlap, with no single view representing the entire system. The requirements for the systems are a synthesis of these views, which necessitates an understanding of the interrelationship between the various views. As the complexity of systems increases, so does the stakeholder's reliance on models to assist in the creation, evolution and understanding of their view of the system' s requirements. A variety of modeling approaches have been developed, each providing a particular perspective of what is being modeled. Thus we have approaches for data modeling, process modeling, behavioral modeling, and object-oriented modeling, amongst others, most having some form of automated support. While most of these modeling approaches have been applied in variety of circumstances, some even to other perspectives (i.e. data modeling applied to process modeling), no single approach applies equally well to all situations. Stakeholders select the approach that best suits their needs and use it to create their set of requirements for the system. In order to synthesize the various sets of stakeholder requirements to form a coherent set of requirements for the systems, the stakeholders views must be correlated, conflicts between the views need to be resolved and any missing information must be addressed. This can be accomplished by correlating the models used by the various stakeholders, since that would ensure that the models were views of the entity. This would be true whether the entity was a system, family of systems, or a domain. This correlation would also facilitate the identification of the impact that a requirement change in view had on the other views of the system. The result would be an efficient and cost effective requirements definition process that produces an accurate set of system requirements, with the capability for quickly accommodating change.

Modeling approaches used today have been developed to support a single system perspective (i.e. data modeling, behavioral, process, object-oriented, etc.) as their primary focus. Some correlation has been attempted, either by modifying the primary focus for application to another perspective (i.e. data modeling approach modified for application to process modeling) or as a secondary output from the tool supporting the approach (i.e. tool supports behavioral modeling but can also produce a data model). Unfortunately, the secondary perspective is rarely supported to the same degree as the primary.

This SBIR will addresses the issues associated with providing methods, and associated automated support, to correlate several models of a system, each created using a different modeling approaches. The method should be one that can be used with existing modeling tools, rather than one that duplicates the modeling capabilities found in those tools. The proposed approach should include, but not be limited to, the identification of an initial set of modeling perspectives for correlation, possible interface(s) required with existing modeling tools, use of the proposed tool for identifying conflicts/ inconsistencies between models, use of the tool to identify impact of changes in one model on other correlated models, possible limitations on use of the tool, and use of tool for various modeling situations such as system models, product line models (family of systems), or a domain models (which includes families of systems).

PHASE I: Define method, and automated support needed, and demonstrate feasibility of approach. Define scenarios that describe use of method in various situations. Additional consideration will be given for proposals that identify possible commercialization path, to include potential military and commercial users of the proposed product.

PHASE II: Develop a prototype implementation that incorporates and demonstrates the approach and support proposed in Phase I. Demonstrate prototype using scenarios based on realistic cases.

POTENTIAL COMMERCIAL MARKET: Commercial companies, like their military counterparts, are developing complex software intensive systems and product lines. Requirements for these systems involve many stakeholder viewpoints, along with associated models, that must be correlated to ensure efficient and cost effective product development. These organizations rely on commercially available tools to support their modeling efforts. A tool that can be used with existing modeling tools to assure that models used on a development are correlated and therefore are views of the same entity would greatly enhance the reliability, supportability, and cost effectiveness of the companies products.

A95-066TITLE:Software Metrics Global Database

CATEGORY: Exploratory Development

OBJECTIVE: Current/past global software metrics databases or repositories are unwieldy, unmanageable, and at a national level and therefore are hard to validate and difficult to use. What is needed is an innovative scheme, design and implementation of a useful global database, where "global" refers to the organization level, not the entire industry.

DESCRIPTION: The proposal shall be based on a two-tiered approach. The first provides for a scheme, design and prototype of a software metrics database to be established and maintained at an organizational level. Organizations of interest include: Program Executive Offices (PEOs) and Program Managers (PMs) responsible for systems acquisitions; Software Engineering Centers responsible for system support; and private vendors developing commercial and/or government systems. Global information/lessons learned, gathered from projects under its responsibility, would be used by an organization to evaluate how well it was doing its various jobs, how efficient its processes were, and if it was improving over time, and then used as basis for corrective actions and improvement programs. The proposal must: provide a scheme for accomplishing each of these functions; address security issues involved with collection, dissemination and use of sensitive system or contractor data and information; provide a validation strategy; and address the acquisition life cycle from requirements definition through government deployment/commercial distribution and support. The scheme shall NOT assume projects are collecting standard metrics but each has implemented its own preferred state-of-the-practice metrics set/methodology. Therefore, a conversion scheme is needed that allows integration/assimilation of the various formats. As a minimum, the proposal shall demonstrate expertise with CECOM's streamlined Integrated Software Metrics Approach (SISMA) and OPTEC' s Software Test and Evaluation Panel (STEP) metrics. In the second tier, the organization would obtain databases of other organizations and extract information/lessons learned for import into, or modification of, its own database for use as appropriate. The proposal shall provide for development of guidance to assist an organization in accomplishing these functions, and shall include

a strategy for time stamping and updating the various database copies. Users would use database information/lessons learned for various life cycle activities as input to those activities for the current or next project. For instance, support data could be used to improve supportability requirements for the next statement of work, or to assure development plans were re-directed to improve supportability of the current project.

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

PHASE II: Develop prototype and provide a demonstration of capabilities. Develop technology transfer mechanisms such as informal seminars and hands-on tutoring.

POTENTIAL COMMERCIAL MARKET: This technology is of prime interest to organizations developing large, complex software systems, both defense and commercial. Consideration will be given those proposals identifying candidate beta sites, pilot projects, and users, from both government and industry.

A95-067TITLE:Speech Recognition System

CATEGORY: Advanced Development

OBJECTIVE: Develop a speech recognition input capability for any Army or commercial Virtual Reality (VR) simulation.

DESCRIPTION: One important aspect of VR is the man-computer interface. The information presented to the user of a VR system is tactile through the use of a glove, aural from speakers, or visual from a screen. The user provides input to the system through the use of the glove or by keyboard or other devices. Input in some very sophisticated system is accomplished by following eye or arm movements. Input methodology could be made quicker, easier, and more realistic if the user was able to verbally communicate with the simulation. Spoken communication is not a simple function. The wide variety, tones, and accents of natural speech, even without the complication of different languages, make for a tremendous challenge for VR input. This effort seeks to develop a speech recognition capability that can be used to more efficiently communicate with the simulated environment. Specifically, a contingency planning training system will be developed that will make use of speech recognition technology. The initial effort will concentrate on scenarios that operational forces (OPFOR) would encounter, but the contingency planning aspects of the project would be easily adapted to commercial applications such as natural disaster response planning, crowd control planning, air traffic control, etc. Follow-on efforts would include expanding the vocabulary of the system, using the system for translation, and adapting the technology to facilitate computer, weapon, or machine operation.

PHASE I: Develop and demonstrate a prototype contingency planning training system (initially for OPFOR) through the use of speech recognition technology. This technology should be adaptable to a wide range of platforms (open architecture). The software should also be easily installed, opened, and used with minimal training. The requirements for the Speech Recognition System (SRS) will serve to increase the realism and response of current and future tactical simulation and training systems. Specific requirements are: 1. speaker independent; 2. near real time reaction; 3. identify both words and numbers; 4. recognize a moderate vocabulary (less than 500 words) with high perplexity; and, 5. recognize continuous speech with an average command accuracy of at least 95%.

PHASE II: Improve the accuracy and increase the vocabulary of the SRS, translation capability to allow NATO interaction, designing and developing a dedicated translation device, and translation of more languages. The SRS will be adapted to control a man-in-the-loop weapon system and a commercial computer controlled milling machine.

POTENTIAL COMMERCIAL MARKET: This program has tremendous dual use possibilities. Training in a VR environment is a growing military market and is also applicable to any local, state, or federal law enforcement personnel, Air Traffic Controllers, fire fighters, machinists, assembly line workers, and hazardous materials transporters. Diplomatic and business interests would benefit from the translation follow-on efforts. Speech Recognition also can be utilized by future systems to facilitate operational input. This would apply to any commercial or military equipment that requires human interaction. Systems that could be controlled by voice commands could mean fewer operators or increased efficiency in programming operations.

A95-068TITLE:Virtual Prototyping for Personal Protective Equipment and Work Places

CATEGORY: Exploratory Development

OBJECTIVE: Develop a virtual tool to support the design of individual protection items and to reduce the hazards of work/living spaces

DESCRIPTION: In virtually all work places and military operations humans are exposed to potentially fatal hazards. Many attempts have been made to mitigate theses hazards and their effects on individuals. Most recently efforts have concentrated on building and testing actual items. This has proven to be expensive and the resulting knowledge is not easily extrapolated to settings other than those actually tested. Research is needed to develop a virtual prototyping tool that can be used to design protective equipment which protects against ballistic insult, penetrating injuries, blunt trauma, and crushing injuries. In addition, the developed tools need to support design of the spaces in which individuals will work, live and travel.

PHASE I: During Phase I, the contractor will review all previous applicable efforts and research in the fields of body armor, anthropometry, computer modeling, ergonomics, and accident investigation. Based upon this review the contractor will develop a roadmap for the development of a proposed tool and an object oriented simulation architecture which supports rapid prototyping of the virtual design tool.

PHASE II: During Phase II, the contractor will implement the virtual design tool using the roadmap and the object oriented architecture developed during Phase I. Following the implementation, the contractor will use the tool to design a prototype ballistic/blast overpressure protective ensemble and a vehicle crew compartment which will minimize the blunt trauma to occupants during vehicle collision while maximizing the occupants' ability to accomplish required tasks.

POTENTIAL COMMERCIAL MARKET: The developed tool will provide significant benefits to the medical industry in areas such as the training of trauma surgeons and the design of treatment facilities. Strong potential exist in the automotive industry for the design of passenger compartments. In addition, the design of individual protective equipment and structures has broad application in military, law enforcement, and fire fighting applications.

A95-069TITLE:Distributed Interactive Simulation (DIS) Applications to the Combined Arms Tactical Training (CCTT)

CATEGORY: Exploratory Development

OBJECTIVE: To develop new and innovative solutions specific to CATT problems areas.

DESCRIPTION: The development of the Close Combat Tactical Trainer (CCTT), the initial system to be delivered under the CATT program is underway and is initially focusing on Armor Close Combat. The CCTT can be envisioned as a system of computer driven combat vehicle and Dismounted Infantry simulators and emulators that control other vehicle models and functions and which work interactively over a computer network. Ultimately, CATT will provide the capability to train the total combined arms force on a simulated fully interactive, real time synthetic battlefield. This capability will be used to train and sustain collective tasks and skills in command and control, communications, and maneuver. As the CCTT work progresses and training requirements matured, several training needs have been identified that require additional R&D. These needs are outlined next.

a. The need exists to develop a low cost voice recognition and voice synthesis interface for the dismounted infantry (DI) modules so that soldiers using the manned module can interface with in a realistic manner. The current CCTT manned modules contain a DI module that allows a squad leader to interact with a semi-automated force (SAF) computer generated squad. The computer interface that the student uses to interact with his computer generated squad consist on a 3D visual display, 2D Planned View Display (PVD), joystick and keyboard. This type of input does not allow the squad leader to interact with his squad using voice commands similar to those that they would use in a combat situation. The purpose of this effort would be to develop a voice interaction system that could supplement/replace the computer interface expected to be deployed (>700) the units should be very low cost (goal: approx one to two thousand dollars per module in production). Additional consideration/goals to be considered include: a connected vocabulary size of approximately 600 words and voice independence (or a training period of less than five minutes); Retraining should not be required for a minimum of three days and perform well when the student is under stress.

b. The need exists to develop a method of implementing a generic set of tactical instructions that represent a class of opponents with similar capabilities. The modeling and simulation community relies heavily upon Semi-Automated Forces (SAF) to model opposing forces (OPFOR). To data the tactics implemented for SAF OPFOR have been to base them on our best understanding of a "real" opponent - usually the expected tactics that would be used by the Soviets in Central Europe. The challenge faced today is that there are many more potential adversaries that can modeled and our understanding of their tactics may range from well understood to almost no understanding. What is needed is a method to develop a realistic SAF that is based, not upon our understanding of how someone will fight, but is based upon the potential tactics that could be deployed by an opponent that has certain types of equipment, fighting in certain types of conditions (desert, mountains, forest, etc; summer, winter, etc; day/night; etc). The resultant tactics should allow for "tuning" such that different degrees of capability can be represented, with the most difficult level being more difficult than would be expected from a skilled experienced opponent with similar equipment.

c. The need exists to develop a low cost large screen visual that can be used in combat vehicle "popped hatch" situations. CCTT manned module's frequently operate tactically in a "popped hatch" mode. Under these circumstances 360 degrees of visibility are required. Current CCTT design utilizes 10 CRT's in lieu of one large screen presentation because of a number of deficiencies in current large screen display systems, such as low luminescence. Any proposed design should allow for a smaller package that the current CCTT design, provide a visual image (brightness, fidelity, etc) as the current design and be compatible with the current CCTT computer image generator (Evans & Sutherland Model 3000). The design must also be rugged enough to meet the mobile CCTT requirements (electronic van mounting).

d. The need exist to develop a set of performance feedback displays for a SIMNET/CCTT type training device that will assist an instructor in debriefing a typical training exercises. The CCTT will contain a data logger and After Action Review (AAR) system which can be used to assist instructors in debriefing students after a training exercise. To date, the AAR displays have collected the network DIS data and provided statistical type displays. It is not often easy to determine from these types of displays what actually occurred. For example, it may be possible to determine that a student fired X number of times and got Y hits, but this does not tell why the student actually got the hits or misses.

In summary, any of the "needs" described above could be, in general, the subject of a separate research proposal with the following Phase I & II objectives.

PHASE I: Explore alternative concepts and develop and demonstrate feasible approach.

PHASE II: Develop comprehensive implementation of best approach from Phase I with the objective of demonstrating the feasibility and effectiveness of the concept.

POTENTIAL COMMERCIAL MARKET: Video arcade and entertainment industry; commercial simulators such as flight trainers and driver trainers.

A95-070TITLE:Targets and Threat Simulators for Development and Operational Testing and Training

CATEGORY: Exploratory Development

OBJECTIVE: Develop threat representative models and simulators to support Developmental and Operational system testing and training.

DESCRIPTION: The Army spends millions of dollars each year developing various threat representative targets and threat simulators to support testing and training. Current problems associated with targets and threat simulators include: size, degree of fidelity, cost, uniqueness, requirements generation and conversion to software. Presented below are four proposed R&D efforts that address specific aspects of the above the problems:

a. Determine feasibility of building a helicopter target, using lighter-than-air technology, which is suitable for use in a training environment. One of the major training problems facing many weapon systems is that full scale targets representing the threat, cost too much to use in a training environment. Reduced scale targets present other problems when used in support of training. The 1/5 scale helicopter target is a prime example. When the 1/5 scale autogyro is used as a training target, problems arise concerning its size, the gunner has trouble acquiring the target because it is so small and the missile often misses the target because of the reduced size. The envisioned large scale helicopter target would be no larger than a 2/3 scale autogyro emulator of a HIND helicopter, weigh no more than 30 lbs, be capable of using the power train from the current 1/5 scale target, be capable of carrying an IR source, be pick-up truck portable, capable of being inflated and deflated in the field, be capable of reliably detonating a STINGER contact fuse and have a per unit cost of $10,000 or less in quantities of 50 or more.

b. Develop a platform for replicating emissions of RF, IR, acoustic and millimeter wave (MMW) signatures of heat signatures. Limitations exist in providing testers and trainers with the required signatures of threat systems to the required fidelity. Signature requirements include: jet engine modulation, propeller modulation, glint and scintillation and ECM signals ; such as flares, suppressors, and IR jammers. Various technologies have been developed that might permit replication of these signatures by electronic methods. This effort examines the feasibility of replicating various threat signatures with a single platform.

c. Develop a threat simulation/SAFOR model for test and evaluation (T&E) applications and establish a quantitative process which validates the performance characteristics and approves tactics and doctrine for this model. A new generation of validated, DIS compliant threat simulations/SAFOR are required to explore the feasibility of performing operational tests in the synthetic environment. Although a multitude of threat simulations and scenarios are currently in use for various Army mission requirements, there is no standard quantifiable process to validate the performance parameters and tactics and doctrine of these threat weapon/SAFOR models to determine their suitability for test and evaluation missions. The validation process and procedures must be flexible enough to handle re-configurable threat models. Using the synthetic environment to perform tests on existing/future Army combat and materiel system is intended to improve the test process and reduce overall acquisition costs. Testing with models and simulations is meant to enhance the live portions of the operational T&E process, not eliminate them. These simulations should take advantage of modern object-oriented design techniques and state-of-the-art technologies in order to be modular, portable, reusable, re-configurable and accurate. Threat representations should accurately depict threat weapon characteristics and OPFOR tactics and doctrine. It is imperative that these threat simulations be DIS complaint in order to have full access to the virtual battlefield.

d. Develop a knowledge based system that will accept military system data in parametric form and weapons systems testing requirements, with various objectives and constraints. Then integrate this data into a meaningful whole with prioritized suggestions for instrumentation and best approach solutions for threat simulators and targets system

concepts and specifications. A requirement currently exists for systems that utilize "artificial intelligence " concepts that will take data from multiple sources, analyze it and then generate systems requirements. Present systems are test based relational databases that are limited to keyword searches, and do not accept knowledge based and are incapable of learning and reasoning about instrumentation and threat target simulation requirements. The envisioned system will be very user friendly and will take advantage of commercial off-the-shelf hardware and software whenever possible. If successful, this system could be used by any DoD test activity to determine instrumentation, targets and threat simulator requirements.

PHASE I: Explore alternative concepts and develop feasible approach.

PHASE II: Implement the best approach from Phase I with the objective of demonstrating the feasibility and effectiveness of the concept.

POTENTIAL COMMERCIAL MARKET: The video arcade and entertainment industry; commercial simulators such as flight trainers and driver trainers; support local or federal law enforcement agencies; support commercial product testing; and possible use as movie props.

A95-071TITLE:Physical Process Modeling & Simulation for Distributive Interactive Simulation (DIS) Environments

CATEGORY: Basic Research

OBJECTIVE: Develop techniques and methods of modeling/simulating dynamic physical processes for real-time applications in synthetic environments.

DESCRIPTION: Existing synthetic environments contain little or at most only a limited capability for modeling/simulating the dynamic effects of physical processes and complex systems. Specifically, existing simulations do not adequately model/simulate structural integrity of buildings, wind effects on smoke and chemical agents, and the spread of fires as a result of weapon effects. This set of "deficiency examples" evolves from an on-going virtual environment application for training dismounted infantry in a DIS environment and is not necessarily comprehensive. Other "examples" are sought and are encouraged and could be the focus of proposed research. For the dismounted infantry training application cited the simulation of the weapon effects on the structural integrity of a building is needed. The model/simulation would include effects of the impact on the building including the associated visual effect (explosion, fireball, smoke). Also, post detonation effects, such as, floor sag or wall tilt, and the effects on personnel from flying or rolling debris during and after detonation are needed. These simulations/models should also communicate their effects to other models in the system, such as, fire initiation and smoke release.

PHASE I: Design algorithms and develop proof of concept demonstration.

PHASE II: Implement developed algorithms and integrate into designated Army virtual environment applications.

POTENTIAL COMMERCIAL MARKET: The proposed development effort would have application in a number of commercial markets including architecture, structural /civil engineering, and entertainment industry and manufacturing.

A95-072TITLE:Language Based Speech Recognition Module

CATEGORY: Engineering Development

OBJECTIVE: Develop a module for a speaker independent continuous speech recognition system that exploits the current parallel DSP/microcomputer system technology. Recognizer should extract the meaning from spoken natural language statements and respond as needed by the operator. The system should adapt to the environment, and permit true language based recognition whether the spoken instructions and quires are issued over a military communications net or directly to a desktop or factory automation computer. Phase II results should translate to a practical implementation in a small add-on parallel DSP/ microcomputer module that interfaces to any standard computer configuration, and permits real time spoken language communications between operator and system.

DESCRIPTION: Most current speech recognizers identify a pre-programmed sound and respond by executing a pre-programmed function. These systems are sound based, not language based. A true language based speech recognizer, as defined here, identifies all phonetic components of the chosen language for statement recognition, extracts the meaning of the statements, and responds to the operator in the same language or as otherwise requested. This system will allow an operator to communicate with a computer, not simply emulate keystrokes or mouse moves with words and phrases. Unfortunately, the computation required for such a system is oppressive and has been previously beyond the capability of all but expensive supercomputers. The latest desktop micros, however, contain CPUs that can perform several operations in parallel. Some companies are now developing boards that permit many simultaneous computations to be done on standard workstations and PCs. Some of these boards can be paralleled on a single backplane for development of massively parallel yet moderately priced DSP /microcomputer configurations. These parallel PCs and workstations will permit practical real time implementation of software algorithms that were previously impossible due to the amount of computation involved.

PHASE I: Develop methodology approaches, and parallel DPS/microcomputer configuration and requirements for the development and implementation of a true language based speaker independent, continuous speech recognition system.

PHASE II: Implement best approach in a laboratory based parallel DPS/ microcomputer system test bed. Develop test scenarios and demonstrate the recognition system's ability to understand and respond, in real time, to spoken natural language statements from various speakers in a variety of operating environments. Provide fully integrated prototype module with documentation, source code and development environment.

POTENTIAL COMMERCIAL MARKET: Most computers have a variety of speech recognizers available... very few are used. Most simply emulate keystrokes or mouse clicks and do not permit true language based operator/system communications using speech. The results of this contract will conclude in the development of a product/system that will understand spoken natural language communications in real time, and in the natural communications style used between people. Since this system will be friendly to use, it will permit easy operator control of all computerized systems, from desktop to factory automation. Since speech is a natural, flexible and very high level means of communicating, this system will reduce operator training time, decrease operator response time, increase operator efficiency, and reduce the total number of required workers or crew size.

A95-073TITLE:Aircraft Vulnerability Model for Missile Test Debris

CATEGORY: Engineering Development

OBJECTIVE: Provide definitive software of use to Major Range and Test Facility Bases and commercial space ports affording protection to civilian, commercial and military aircraft from debris resulting from normal missile test operations. This software will provide an invaluable tool when used in pretest planning and real time test execution through which hazards to aircraft operating in proximity to or in adjacent airspace can be quantified. This allows for control of risk through prudent use of airspace evacuations and advance notice to aircraft operating in the hazardous airspace. Methodology will employ standards acceptable and adaptable to all ranges or commercial space ports.

DESCRIPTION: It is known that current Army test scenarios for high performance, high altitude missile systems as well as to and from orbit commercial and military vehicles will produce debris either nominally or as a result of any number of inflight failures. The debris has the potential to be carried great distances in significant concentrations as a result of high wind fields aloft. Because of this phenomenon, this debris can present a hazard to aircraft operating in the vicinity through direct engine ingestion, impact with critical control systems or violation of passenger environment containment systems. At the present time, only limited work has been performed in characterizing debris from various aspects of testing or reentry breakup. Stochastic meteorological models with aircraft vulnerability data bases are required to provide a means of quantifying under what conditions debris concentration and composition constitutes a clear navigation hazard to aircraft. It is proposed that this standard software provide sufficient versatility to be universally accepted over a wide range of geographic and test diverse ranges and space ports.

PHASE I: Work will entail expansion of existing efforts to define hazardous vehicle debris characteristics and calculated risk to private, commercial and military aircraft type. Phase I will develop new world-wide stochastic meteorology models, using existing standard range atmosphere models with monthly and daily updates, for propagation

of debris into aircraft operating zones delineated by altitude. Clearly, data bases will need to be developed to support these models. Successful model agreement with empirical data will be required for continuation into the next phase.

PHASE II: Important to universal adoption will be to incorporate major features of the complex models above into a methodology able to produce sufficient accuracy on a variety of smaller computer platforms. Developed algorithms will be incorporated into software able to be processed on common personal computer platforms such as high end DOS, Macintosh or UNIX workstations. Software will be validated by empirical data in this phase and made available to a widespread set of users with user feedback incorporated into subsequent versions for further verification and ease of use.

POTENTIAL COMMERCIAL MARKET: This technology has direct impacts on the space and aviation industries. Immediate application will be a definitive risk management methodology for indigenous and non-participant incident aircraft. These models will lead to reduced over-conservatism/speculation employed currently by test ranges/space ports thus allowing less restrictive test scenarios and inevitably lower developmental cost of, to and from orbit vehicles. This will also give the U.S. a competitive edge in the space test market. Taken to an extreme, this software could prevent the eventual tragic consequences of an aircraft or space vehicle encounter with a swarm of airborne debris.

A95-074TITLE:Hybrid Foil/Magnetic Bearing

CATEGORY: Exploratory Development

OBJECTIVE: Combine a foil bearing and a magnetic bearing into a single compact unit.

DESCRIPTION: Foil bearings and magnetic bearings offer substantial advantages over conventional bearings in high temperature gas turbine applications, in that they do not require oil for lubrication. Foil bearings have start up problems, but at higher speeds have a good load capacity. Magnetic bearings, on the other hand, have good start up characteristics, but need a back up bearing. The combination of the two should have good synergistic effects, with the main benefits expected to be lower weight and cost, as well as longer life and reliability.

PHASE I: Select compatible foil and magnetic bearings and integrate their designs into one unit. Perform a system study showing the advantages of the combined bearing in a high temperature engine application, such as an existing Army engine. Plan a Phase II test to demonstrate the advantages of the combined bearing system.

PHASE II: Procure/construct the hybrid Foil/Magnetic Bearing and perform a rig test to demonstrate its advantages.

POTENTIAL COMMERCIAL MARKET: A Hybrid Foil/Magnetic Bearing will have a wide application potential for main propulsion engines, APUs (Auxiliary Power Units), natural gas compressors, and most rotating machinery.

A95-075TITLE:Advanced Engine Sensors and Controls

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate sensors and controls for real-time monitoring, control and optimization of Diesel or gas turbine engines.

DESCRIPTION: Laboratory research has demonstrated that it is possible to sense and control unwanted disturbances in engines, thus broadening the operating envelope through the application of real-time, dynamic control strategies. An example is the compressor surge and stall control demonstrated at MIT. It is possible to project additional application of advanced control concepts, especially for combustion control in Diesel or gas turbine engines. A major barrier to the implementation of these concepts is the bulk and complexity of sensors and actuators in any control scheme. However, recent advances in Micro-Electro-Mechanical Systems (MEMS) and hybrid electro-optic sensor technologies indicate that it may be possible to develop compact, robust sensors and actuators for engine application, for example, in fuel and

air-flow control, etc. Innovative concepts are sought which will lead to the development and integration of effective real-time control systems.

PHASE I: Determine the most effective control strategies for engine control and optimization. Develop preliminary designs for sensors and actuators. Assess the potential performance resulting from the application of the proposed system.

PHASE II: Develop prototypes of selected designs, incorporate into suitable engine. Determine effectiveness of systems and effect on engine performance parameters.

POTENTIAL COMMERCIAL MARKET: These technologies have potential broad application to both military and civilian engines.

A95-076TITLE:Technology for Turboshaft Engines

CATEGORY: Exploratory Development

OBJECTIVE: To develop innovative gas turbine engine component technologies which will provide future Army turboshaft engines with increased power-to-weight ratios and/or reduced specific fuel consumption.

DESCRIPTION: The Integrated High Performance Turbine Engine Technology (HPTET) initiative is an integrated DoD/NASA/ARPA industry program structured to meet current and emerging propulsion needs by doubling propulsion system capability around the turn of the century. The general path to doubling propulsion system capability includes, but is not limited to; higher maximum temperatures to increase the output per unit airflow; less weight per unit airflow is required to increase the output per unit weight; and increased component efficiencies for decreased specific fuel consumption while maintaining or increasing component durability and life and maintaining or decreasing cost per unit output. To achieve the necessary future propulsion technology advances, technology strides in the compression systems; combustion systems; turbine systems; controls and accessories; and mechanical systems of a gas turbine engine are required. Specific propulsion technology development areas include high pressure ratio, lightweight compressors; combustors that are lightweight with reduced pattern factors and higher inlet and outlet temperatures; turbines with increased temperature capability, reduced cooling air requirements, high work extraction, and are lightweight; advanced materials/materials systems and innovative structural concepts to accommodate the stresses developed at the required higher speeds, operating temperatures, and reduced weight. Materials under consideration include Ti-based MMC's for the compressor; high temperature materials such as CMCs for the combustor, and a combination of materials with higher temperature capability such as single crystals, intermetallics and composite material combinations for the turbine. Also innovative blade/vane attachment concepts, advances in cooling technology, and concepts involving replacing disks by rings are being pursued. Thus, future propulsion systems necessitate further development in aerothermodynamic design capability for improved component efficiency levels and improved control of heat transfer; higher temperature and lightweight materials; innovative structural concepts; and compatibility of these developments with affordable manufacturing processes.

PHASE I: Define a novel concept or innovative technology which is potentially applicable to future turboshaft engines. Based on the technology to be pursued, devise a methodology which addresses and substantiates the feasibility of the proposed approach. Define the potential benefits achievable through the application of the proposed concept/technology.

PHASE II: Pursue the technology defined in the Phase I effort. Fabrication and component or subcomponent testing should be perform ed to substantiate the technology and its intended end application. The technology should be suitable for transition into a turboshaft engine.

POTENTIAL COMMERCIAL MARKET: Aircraft gas turbine technology is vital to the US industrial base. Because aircraft gas turbine technology is applicable to both military and civil engines, achieving the IHPTET goals can ensure continued US preeminence in the increasingly competitive international turbine engine marketplace well into the 21st century.

A95-077TITLE:Light Weight Small 3-10Kw, 120Vac, 60Hz, Diesel Generator Sets

CATEGORY: Advanced Development

OBJECTIVE: Develop a light weight small diesel generator set, 3-10Kw, 120 Vac, 50/60Hz, 3-phase, using VSCF (variable speed constant frequency) permanent magnet generator, composite housing and high speed diesel engine.

DESCRIPTION: The Army is currently replacing its extensive inventory of small generator sets. There is potential to reduce the size, weight, noise, and fuel consumption by using these newer technologies. VSCF technology offers the opportunity to de-couple the engine speed from the output frequency and run the engine at speeds proportional to the load. At reduced loads both fuel consumption and noise may be reduced. Higher engine speed can lead to smaller and lighter engines and generators. Composite technology, if done correctly, offers the potential for stronger, lighter housings.

PHASE I: Preliminary design, components identification, and composite housing design and material selection for a light weight, small generator set in the 3 to 10Kw range.

PHASE II: Detailed design, fabrication and testing of the system. Application of appropriate standards validate the design concept.

POTENTIAL COMMERCIAL MARKET: Potential to replace obsolete small commercial generator sets.

A95-078TITLE:Low Cost Electronic Controls for Small 3-10Kw, 120Vac, 60Hz, Diesel Generator sets

CATEGORY: Advanced Development

OBJECTIVE: Develop a low cost control system based on modern control techniques for small diesel generator sets, 3-10Kw, 120 Vac, 60Hz.

DESCRIPTION: The Army is currently replacing its extensive inventory of small generator sets. The control systems on these sets date from the 1960's and 1970' s and should be replaced by current technology. The control system should be able to control speed and voltage, monitor elementary faults (oil pressure, overheat, etc.), and have some display capability. There are electronic control systems available, but they are designed for larger engines and are expensive when compared to the cost of a small diesel generator set. A low cost control system needs to be developed that will meet the Army's small generator set requirement. The control system should be generic enough to be used on all small sets of the same configuration. Production cost (not to be confused with developmental cost) should be less than $500 in lots of a thousand or more.

PHASE I: Preliminary design, components identification, and software preliminary design and flow charting.

PHASE II: Detailed design, fabrication and testing of the system. Application to appropriate generator set to validate the design concept. This effort addresses S&T thrusts in advanced land combat and the Star 21 focal values for electric drive technology.

POTENTIAL COMMERCIAL MARKET: Potential to replace obsolete controls on small commercial generator sets.

A95-079TITLE:Low Cost, High Pressure, Electric Metering Pump for Liquid Fueled, Expendable, Tactical Missile Propulsion Systems

CATEGORY: Exploratory Development

OBJECTIVE: Development of a low cost, high pressure electric metering pump for liquid fueled, 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 solid rocket. On-demand thrust control will be required, which will dictate the use of non-traditional liquid (or gel) based propulsion systems such as: monopropellant rocket, hybrid rocket, bi-propellant rocket, and air turbo ramjet (ATR). To obtain high performance (thrust), the reactors of these systems must operate at relatively high pressure levels (1000 to 2000 psig), thus necessitating even higher propellant supply pressures (1500 to 3000 psig). In addition, pressurized fuel is also required by turbojet, turboprop, and liquid fuel ramject propulsion systems for effective injection into the combustor (required pressure levels are generally under 500 psig). A major disadvantage with the utilization of high pressure propellants is the prohibitive weight penalty associated with high pressure tankage required for direct expulsion propellant delivery systems. The requirement exists for tactical missile propellant pressurization and delivery systems that can be utilized with light weight, low pressure (less than 50 psig) or unpressurized tankage. One attractive method for achieving this objective is a high pressure electric metering pump that could act as both a fuel pressurization device delivering high pressure fuel from low pressure tankage, and as an on-demand fuel metering device that could be employed by the missile as the principle fuel control device. Technology is required for development of low cost light weight electric pump that could be utilized in liquid fueled tactical propulsion systems. It is expected that such a pump would exploit recent technological advances in high speed electric motors (permanent magnet or switched reluctance) and in power switching transistors. The pumps to be developed must incorporate the following features: compatibility with common liquid propellants (e.g. hydrazine, JP-10, IRFNA, MMH, N204), functionality with gelled propellants, ability to deliver fuel from low pressure tankage (less than 50 psig but preferably ambient pressure), insensitivity to pressure fluctuation (inlet and outlet), on-demand delivery of a continuum of low rates (10:1 or greater turn down ratio required), on-demand flow rate control from an external computer through a command signal (either analog or digital), ability to supply flow at the pressure required by the engine over the full thrust range, self-contained system with minimal sensors and a simple control system (no control system is desired), low cost design consistent with tactical missile systems, minimized weight, minimized weight, minimized volume, self-contained sensors and feed-back control (if required), 10 year shelf-life, compatibility with tactical missile environment (storage, transportation, and operating), 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 pump design should employ generic technology, and should be scaleable to accommodate a wide range of maximum flow rates (.1 to 50 lbm/sec).

PHASE I: Under Phase I effort, a heavy-weight, high pressure electric metering pump shall be designed, developed, fabricated, and demonstrated. This system shall be sized for an ambient inlet pressure, a 1700 delivery pressure, and a maximum .5 lbm/sec flow rate. The pump must be designed to pump liquid hydrazine, and to be powered and controlled through bench top breadboard electronics capable of receiving flow rate commands (analog or digital) from a personal computer. The pump should incorporate as many of the desired features as possible. The contractor may demonstrate the system utilizing water as the delivered liquid. The system must be demonstrated over a wide range of flow rates. 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 evaluations utilizing hydrazine. Sufficient expendable/replaceable hardware must be delivered to support the Government test program.

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 this effort, over a wide range of conditions (transportation, storage, operational). Several devices shall be delivered to the Government for independent evaluation.

POTENTIAL COMMERCIAL MARKET: Commercial space launch vehicles and commercial airliners could utilize the high pressure low cost electric pump developed for tactical missile propulsion systems to significantly reduce acquisition and operating costs.

A95-080TITLE:Particulate Simulation in Solid Propellant Rocket Exhaust Plumes

CATEGORY: Basic Research

OBJECTIVE: To develop innovative models for the basic physical and thermochemical processes describing two-phase, gas-particle, flows which can replace the existing but inadequate models which currently limit the technology.

DESCRIPTION: Simulation and analysis of many of the aero-propulsion interaction problems of missile development such as nozzle erosion, base heating, and exhaust plume signature require high fidelity models for two-phase, gas-particulate, flows. Computational fluid dynamic models are available which analyze the two-phase processes in solid propellant rocket nozzles and exhaust plumes; however, with the advent of newer algorithms (e.g. finite-volume Roe/TVD upwind solvers) and unstructured grid methodology, there is an opportunity to revolutionize the solution methodology for particle convection in complex, three -dimensional transient and steady state flows. The representation of the particulated motion to date has utilized assumptions and empirical relations which have been found to be inadequate based on recent comparisons with varied sets of data. This present inability to deal with the basic physics and thermochemistry with regard to particulate formation (size), particle/particle interactions, particle/boundary interactions, and particulates in turbulent zones (nozzle boundary layer, plume shear layer, and missile base region) precludes obtaining an accurate representation of the two-phase flow using the best available numerics. New, innovative, and improved approaches are needed to overcome these limitations with research directed towards:

1. Numerical formulation - Particle solution algorithms which are compatible with the gas-phase numerics and adaptive grid schemes, efficient treatment of stiff nonequilibrium source terms - review Eulerian vs. Lagrangion approach.
2. Drag/heat transfer laws - Require significant upgrade as found from detailed Monte Carlo simulations which indicate heat transfer correlations in error by large factors; also supercooling issues and phase change in general.
3. Particle/particle interactions - Not accounted for; require agglomeration models, numerics to deal with size change.
4. Particle/turbulence interactions - Varied approaches proposed, require review and utilization of approach consistent with numerics implemented and turbulence model utilized.
5. Coupling strategies - Gas/particle coupling problem dependent; time-asymptotic snapshot approach entails converging particles once every n-th gas-phase time-step (snapshot approach). For time-accurate calculations, require strong-coupling at each time step. May require non-dilute extension to formulation (void fraction for volumetric effects) for local regions with high concentratoins (e.g. behind the Mach disc, near centerline).
6. Particle/boundary interactions - Need improved formulations for wall interactions (Euler and viscous), methods for heated reflected particles that come back into flow, slag layer approach for entrapment into surface boundary layers, etc.
7. Particles from multiple sources - Ability to heat particles of same size from different origins (e.g from four motors) coexisting at a point, may need probabilistic approach.

PHASE I: Technical approaches will be formulated for each of the above problem areas for inclusion into computational models utilized by the exhaust plume community. At least one innovative model will be coded and implemented to assess the extent of improvement.

PHASE II: The additional model improvements formulated in Phase I will be finalized, documented, coded, and incorporated into an existing Government rocket exhaust plume flowfield code. The improved plume flowfield code will be run against the unmodified code for a series of test cases which can demonstrate the ability of the advanced physical and thermochemical two-phase, gas-particulate, flow models to overcome current limitations.

POTENTIAL COMMERCIAL MARKET: The past few years has seen an enormous growth in both the development and application of computational fluid dynamics throughout commercial industry. The modeling of two-phase, gas-particle, flows is key to the understanding and control on many industrial activities such as coal-fueled combustion, bulk materials handling, solids processing, and pollution control. Revolutionary and innovative advancements in computational fluid dynamics for two-phase, gas-particle flows would open a vast new area to this technology.

A95-081TITLE:High Torque Density Electric Traction Motor

CATEGORY: Exploratory Development

OBJECTIVE: The objective is to examine and develop a high torque density (ft- lbs/ft3) electric traction motor suitable for application in tracked combat vehicles.

DESCRIPTION: The essential performance capability sought is 1600 ft-lbs/ft3 including the motor controller 300 kw deliverable over a 9:1 speed range, liquid oil-cooled at 250 degF oil temp. and a minimum efficiency over the 9:1 speed range to max rpm of 90%. Length/diameter, including any gearing but excluding the controller should fall between X & Y. The motor may be AC or DC, PM or other, but should not exceed 700V DC equivalent.

PHASE I: The contractor shall design the motor and analyze its performance with special consideration to the efficiency, accuracy, and reliability of the mechanism controlling the torque over the speed range. A thermal analysis of the heat generation and dissipation shall be performed.

PHASE II: The contractor shall build first a bench test model of the controller and test it over the equivalent motor performance range. The contractor shall then build and test a complete motor and controller, testing it over the complete power and speed range.

POTENTIAL COMMERCIAL MARKET: Compact electric motors in this size range have a variety of commercial applications: Heavy duty road and off-road machinery, industrial applications where space or weight is at premium 8-10 inches length and 20-23 inches diameter, and marine applications such as ferries.

A95-082TITLE:Advanced Ground Vehicle Propulsion Technology

CATEGORY: Exploratory Development

OBJECTIVE: The objective is to examine and develop technologies to increase power density with respect to volume and/or weight, increase efficiency, reduce specific heat rejection, and provide reliability improvements for high output military diesel engines.

DESCRIPTION: Anticipated future high output diesel engine operating conditions include cylinder heat loading greater than 4 horsepower (HP) per square inch (piston surface area), 4 cycle brake mean effective pressure exceeding 300 psia, and brake specific heat rejection to coolant of 12 BTU per HP-Min or lower. Technology areas addressing these targets as well as that of reducing engine weight include, but are not limited to: 1) high temperature tribology (i.e., tribological system approaches should address high temperature lubricant capability, and friction and wear minimization in areas of borderline lubrication); 2) insulative componentry (i.e., components to be considered shall include pistons, rings, liners, valves, valve guides and seats, head or head combustion face and intake and exhaust ports and novel monolithic and coating applications for these components will be considered); 3) fuel injection system/ combustion enhancement (i.e., technologies to be considered include ultra-high pressure injection or other combustion technologies enabling diesel combustion toward stoichiometric conditions without fuel economy degradation); 4) high efficiency, broad range, low inertia and high tolerance to high exhaust pressure, and concepts to use a turboalternator as a compounding unit are being considered for electric drive applications); and 5) engine lightweight structural concepts (i.e., requirement exists to provide dramatic weight reduction in diesel engine structure and componentry). Also concept designs presented shall be consistent with Army initiatives to reduce operating and support costs. Two generic cost drivers 1) causes of electrical/mechanical replacement costs and 2) causes of fuel/fuel distribution costs are directly applicable to this topic. It should be noted that the contractor may select component technologies supporting the above overall objective of the advanced diesel engine area. It is not expected that contractor should necessarily develop a technology system addressing all the areas discussed above.

PHASE I: The contractor shall research technologies and prove concepts from a feasibility standpoint. Concepts designs shall be presented and substantiated via analytical calculations, drawings or in the case of hardware initial bench type testing.

PHASE II: Concepts shall be demonstrated in Phase II using a single or multicylinder engine with operating conditions similar to those of a high output military engine. Steady state as well as transient testing for 100-hours or more may be required.

POTENTIAL COMMERCIAL MARKET: Although commercial and military engines are of different power ratings, the trend for commercial engines is also toward increasing high brake mean effective pressure and higher operating temperature. The engine areas of interest presented are all generically applicable to future commercial diesel engines currently under consideration.

A95-083TITLE:Fuel Injection/Combustion for Advanced Military Diesel Engines

CATEGORY: Exploratory Development

OBJECTIVE: The objective is to examine and develop advanced diesel fuel injection systems and other combustion enhancement techniques to allow substantial increased engine power density, increased fuel economy, lower smoke signature as well as lower emissions and wider fuel tolerance.

DESCRIPTION: Future military diesel engines will be required to operate under very high output conditions approaching 1.5 HP per cubic inch displacement. Fuel injection system/combustion enhancement technologies are being sought to meet the above objectives. Technologies with potential to accomplish these objectives such as staged injection, ultra high pressure injection as well as other techniques which would enable diesel combustion to approach stoichiometric conditions without fuel economy degradation are being sought. To focus the response to this topic, it is emphasized that the trend in military diesel engines is toward four valve, open chamber, quiescent, alternative fuel combustion systems in which the distribution/mixing of the fuel with air is predominantly a function of the injection system. Other novel approaches to achieve high engine power density however will also receive consideration. Concept design presented shall be consistent with Army initiatives to reduce operating and support costs with respect to fuel distribution.

PHASE I: The contractor shall research promising engine technologies and prove concepts from a feasibility standpoint. Concept designs shall be presented and substantiated via analytical calculations, drawings or int he case of hardware initial bench type testing.

PHASE II: Concepts shall be demonstrated in Phase II on a single or multicylinder engine with operating conditions similar to those of a high output military engine. Steady state as well as transient testing for 100-hours or more may be required.

POTENTIAL COMMERCIAL MARKET: Although commercial and military engines are of different power ratings, the trend for commercial engines is also toward high brake mean effective pressure. Techniques to enhance combustion to meet the stated objectives are applicable to commercial diesel engines as well.

A95-084TITLE:In-Line Generator for Light Tactical Vehicle Applications

CATEGORY: Advanced Development

OBJECTIVE: To design, fabricate and test generators suitable for incorporating into the driveline of light tactical vehicles. The generators will provide utility power at 120/208 volts, 60 Hz. This approach provides an alternative to towed power sources that simultaneously improves mobility and deployability of systems requiring redundant power sources, allows for rapid set-up and minimum time delay to full power operation, and reduces power supply O&S costs. The product of this effort should be a prototype machine(s) adaptable to both direct assembly line manufacturing integration or retrofit of existing vehicles. The vehicle in-line generator concept would likely be limited to vehicles used in dedicated applications for specific military missions.

DESCRIPTION: The vehicle in-line generator concept has been verified in a medium tactical truck (2.5 - 5 ton). That generator adds 230 kg to the vehicle weight; as the source of redundant electrical power for critical missions, the in-line generator eliminates a 2300 kg MIL-STD 15 kW towed power unit, reducing power source weight by 90% and

eliminating all of the towed unit volume. The problem to be addressed here is to maximize the power output of an in-line synchronous generator in a package that will meet the far more severe installation and weight constraints of the HMMWV and other light tactical vehicles. The overriding consideration demands that the in-line generator does not degrade the vehicle operability, mobility, or reliability. The unit should be as short as possible; it must not be more than 33 cm long, and should not weigh more than 100 kg. It must meet the electrical performance requirements of MIL-STD 1332(B), Class 2B, for utility power sources. The design shall include engine/transmission interface considerations to the 6.2 and 6.5 liter diesel engines used in the light tactical vehicles. Innovative design approaches, advanced materials, and highly effective cooling techniques that lead to high specific power (kW/kg) and high power density (kW/m3) in packages constrained by engine speeds and physical dimension limits are to be pursued. One design shall be for 10 kW at 1200 r/min, another for 20 kW at 1800 r/min, or as near to these values as can be obtained within the size/weight constraints, including the generator controls/voltage regulator in the weight allowance. Military applications include many elements of C4I systems, contact maintenance, mobile medical/dental systems, virtually all dedicated vehicle/shelter systems, emergency power needs, etc.

PHASE I: Perform extensive preliminary design the two principal generators, and document the designs with preliminary drawings. Include discussions of the electrical, thermal, and mechanical performance planned, and the cooling techniques proposed.

PHASE II: Complete the detailed design of the selected unit(s), fabricate, test and deliver the resultant product(s) to the Army for integration into a HMMWV or other light tactical vehicle.

POTENTIAL COMMERCIAL MARKET: Successful demonstration of this technology in light tactical vehicles would provide a clear path for commercial application by vehicle manufacturers or aftermarket sources. The engine class being addressed is found in many full-size pick-up trucks and light delivery vehicles being manufactured today, and the concept is extendable to smaller, lower power units. The vehicle in-line generator concept is particularly useful for remote site or off-road use in construction, communications, maintenance and repair applications. It provides a means to reduce/eliminate pilferage and vandalism to equipment left in the field. Maintenance is automatically taken care of with normal vehicle maintenance, eliminating in-field servicing demands. The technical knowledge gained from performing this SBIR effort is a primary candidate for Technology Transfer from the DOD to the civilian sector for commercialization. The recreational vehicle market is a principle industrial base for this technology.

A95-085TITLE:Space Power Beaming with Mid-Infrared Lasers

CATEGORY: Exploratory Development

OBJECTIVE: To advance energy conversion concepts for powering satellites while they traverse the earth's shadow using high energy infrared lasers as the power source.

DESCRIPTION: Space power beaming, or the remote powering of satellites using high energy lasers (HELS) as a power source is now being seriously considered by several large corporations and government agencies, including NASA, DOE, and DOD. The idea is potentially attractive because as satellites pass into the earth' s shadow, their onboard batteries are drained prior to their next solar recharge. Thus, the powering of satellites with lasers could extend satellite service life. Related efforts to convert infrared laser energy are being pursued by DOD and NASA researchers for space propulsion. The NASA long range planners are also interested in this and related technologies in order to overcome the 2 week long lunar "night". Currently, space power beaming advocates are considering HELs with wavelengths able to be absorbed by conventional solar panels. This restricts the laser devices being considered away from existing mature IR HEL technologies. We propose research into methods of energy conversion that would apply to IR laser wavelengths (from 1-10 microns).

PHASE I: Early efforts should provide a thorough study of the problems associated with IR laser energy conversion in space. An innovative approach should be proposed and designed.

PHASE II: Second phase efforts should focus on fabrication of hardware and demonstration of results using HELs and vacuum chambers available at the Army's High Energy Laser Systems Test Facility (HELSTF).

POTENTIAL COMMERCIAL MARKET: Innovative research into infrared energy conversion has wide commercial application. Techniques for space power beaming, once established, could potentially feedback through the energy conversion economy.

A95-086TITLE:Bifunctional and Catalytic Antibodies

CATEGORY: Exploratory Development

OBJECTIVE: Investigate the potential of using bifunctional and catalytic antibodies in Light Addressable Potentiometric Sensor (LAPS), Fiber Optic Waveguide (FOWG) Sensor, and Planar Optic Waveguide (POWG) Sensor assays. Other technologies which use these antibodies and can detect materials of interest to ERDEC will also be considered.

DESCRIPTION: Current assay protocols with the sensors listed above involve standard immunoassay techniques. The use of bifunctional and catalytic antibodies would serve to simplify these assays, thus reducing the number of bioreagents, and, in turn, the bioagent logistical and stability requirements.

PHASE I: An assay of interest to ERDEC shall be developed using bifunctional and/or catalytic antibodies for either (in order of priority) the LAPS, FOWG, or POWG. The assay must be equal or superior to current assay sensitivities. Recommended assays are: Staphylococcal Enterotoxin B, Botulinum Toxoid, and Bacillus Globigii. The offeror may feel free to suggest an assay of his/her own choosing, especially for a viral assay. Protocols for the synthesis/formation, purification, and storage of the antibodies shall be developed.

PHASE II: The results of the Phase I effort shall be continued and optimized. At least two more assays of interest to ERDEC on dissimilar materials (i.e. toxin and bacteria, not two toxins) shall be developed and optimized. Protocols for the synthesis/formation, purification, and storage of the antibodies shall be developed. The properties of the antibodies shall be fully characterized to include crossreactivity to the other assay materials and to the stability in solution for 24 hours at 37 degrees Celsius and in a lyophilized state at 60 degrees Celsius for one week.

POTENTIAL COMMERCIAL MARKET: The results of this work will offer improved assays for clinical, diagnostic and environmental applications.

A95-087TITLE:Immunopotentiation Vaccine Delivery Systems for Sustained, Controlled Release of Antigens and Induction of Prolonged Immunity Following a Single Dose

CATEGORY: Exploratory Development

OBJECTIVE: Develop adjuvants for immunopotentiation vaccine delivery systems for sustained, controlled release of antigens and induction of prolonged immunity following a single dose.

DESCRIPTION: This concept has been termed either single-step (oral) or single-shot (parenteral) immunization. Delivery systems are modulated to potentiate the immune response either by delivering the antigen (and adjuvant or adjuvants) either over a prolonged period of time or in a predetermined sequence or by incorporating substances with immunoadjuvant properties (e.g., lecithin and certain biodegradable polymers) as carriers within the delivery system. Genomic immunization with the DNA coding for the antigen or peptide fragment thereof, either naked or expressed in a live vector, represents another approach under development. Particular emphasis should be given to delivery systems designed to achieve single-step/shot immunization.

PHASE I: Develop single-step (oral) or single-shot (parenteral) immunopotentiation vaccine delivery system. Demonstrate induction of prolonged immunity following a single dose to an antigen relevant to the medical biological defense research program.

PHASE II: Demonstrate nonpathogenicity and self-limiting nature of the delivery system and efficacy to the extent of producing protective immunity with a single immunization in an acceptable mammalian model.

POTENTIAL COMMERCIAL MARKET: A step vaccine delivery system as described has extensive potential medical application in both the military and private sector.

A95-088TITLE:Methods for Monitoring and Semi-Quantitative Assessment of Circulating Hormones

CATEGORY: Exploratory Development

OBJECTIVE: To develop immunochemical test strips for detection of hormones and their metabolites in body fluids such as blood, urine or saliva.

DESCRIPTION: Current methods to pinpoint phase of hormonal cycles require daily blood samples and expensive laboratory analytical procedures. Test strips using immunochemical techniques to indicate ranges of key hormones or their metabolites in blood or urine would allow for more efficient monitoring in quasi -real time. One example would be to monitor urinary metabolites of estrogen and progesterone in order to categorize women into one of several phases of the menstrual cycle.

PHASE I: Demonstrate the feasibility of a semi-quantitative test strip for detection of circulating hormones or their key metabolites in whole body fluids with minimal sample preparation.

PHASE II: Production and testing of a consistent product, including immunochemical reagents, using all relevant QA/QC and GMP protocols. A direct comparison with standard direct radioimmunoassay of the same specimens should be made, as well as extensive tests for cross-reactivity and interferents.

POTENTIAL COMMERCIAL MARKET: The results of this work would have applications wherever rapid, inexpensive assessment of hormones or their metabolites was required. Examples include human and animal research involving female subjects, and monitoring of disease states involving hormonal imbalances.

A95-089TITLE:Immersive Visualization of Complex Situations for Mission Rehearsal

CATEGORY: Exploratory Development

OBJECTIVE: To develop and evaluate a prototype system which will facilitate the management of and training for complex missions and situations by providing an immersive, interactive, multi - dimensional model of the significant concrete and abstract characteristics of the situation.

DESCRIPTION: Virtual Environment (VE) technology applications are usually used to provide realistic representations of a physical reality. This may be the surface of another planet, a planned building, or the structure of a molecule. Many of the same technologies (e.g., computer image generators, computer models, and helmet mounted displays) can be used to produce visual representations of abstract data that bear little or no relationship to its physical appearance. The central thesis to be explored and exploited in this research is that the management of many complex real world situations can be improved by providing interactive immersive multi - dimensional models of the significant concrete and abstract characteristics of those situations. Examples of such situations are: planning and conducting peacekeeping and combat operations, weather forecasting, disaster management, and fire fighting. The same technology should improve the training for people who manage those situations. For example, a forest fire could be represented on a database of the actual terrain, with color changes to show different temperatures, and fire fighters represented as icons. Realistic modeling of terrain, weather, fire fighting techniques, and other significant factors could be used to explore predicted changes in the situation over time, to include identifying problem situations and fire fighters at risk. User control of viewpoint would permit examination of specific situations in detail, or obtaining a perspective on the overall situation. User control of other aspects of the simulation (freeze, playback, etc.) should permit greater exploration of alternatives and enhance effectiveness. The representation of a military peacekeeping operation should be similar, with estimated degree of threat in geographic area or the time required to provide additional support to a unit being some of the significant variables represented.

PHASE I: Identify requirements for an off-the-shelf generic system which would meet the needs of at least one military and one non- military application. Develop system functional specifications for a prototype system and identify commercial off-the-shelf hardware and software required, to include databases and models.

PHASE II: Develop the prototype. Develop a military application and evaluate its use. Modify the prototype based on the results of the evaluation. Develop and evaluate the use of non - military application.

Phase III: Implement and market the non - military and military applications.

POTENTIAL COMMERCIAL MARKET: Many complex real - life situations have an inherent three - dimensional representation, and would therefore be appropriate for use with this type of technology. Examples include: air traffic control, weather forecasting, ground traffic control, interpretation of complex audio or visual signals (including sonar returns and sonograms), fire fighting (building and forest), emergency or disaster management, planning and conducting peacekeeping operations, and civilian crowd control.

A95-090TITLE:Measurement of Stress Adaptability

CATEGORY: Exploratory Development

OBJECTIVE: To develop a screening measure that can be used to identify individuals who can perform effectively when confronted with novel situations that they have not been trained to respond to.

DESCRIPTION: The contractor will develop a conceptual model for the measurement of adaptibility, specifications for one or more measures to be developed, and a validation of the adaptibility measures.

PHASE I: In Phase I the contractor will develop the conceptual model for the measurement of adaptability. The model will specify what types of characteristics are hypothesized to contribute to adaptability and how they are hypothesized to interrelate. The specifications will identify the type of measure or measures to be developed (personality, biographical, cognitive, etc.), the dimensions to be measured, the plan for item development, the type of items to be developed (multiple choice vs. open-ended, scenario - based vs. other, etc.), the type of scoring mechanism to be used, and the content dimensions to be addressed; and will present sample items. The plan for initial validation of the measure or measures will identify the type of criteria to be used and the manner in which these criteria will be used.

PHASE II: In Phase II the contractor will develop the adaptability measure or measures, will develop the criterion measures, will administer both the adaptability and criterion measures in conducting a validation of the adaptability measure/s, and will analyze the validation data.

Phase III: The contractor will demonstrate the applicability of these measures to civilian markets where change is frequent.

POTENTIAL COMMERCIAL MARKET: The adaptability measure developed will be sufficiently generic to have both military and civilian applications. The need to be able to adapt to changing situations is equally important in both types of environments. Just as it is important in the military to know who can successfully adjust to changes in assignments and missions, it is important to know who can successfully adjust to changes in the civilian work force. The measure to be developed has potentially high utility as a screening tool, particularly in environments where change is frequent and an ability to adjust to such changes is critical.

A95-091TITLE:Neutralizing Monoclonal Antibodies for Specific Toxins and Threat Agents

CATEGORY: Basic Research

OBJECTIVE: Provide neutralizing monoclonal antibodies for specific toxins and threat agents.

DESCRIPTION: Using traditional approaches or novel techniques of in vitro stimulation of human spleen or peripheral cells or recombinant conversions of mouse monoclonals, produce humanized neutralizing monoclonal antibodies with specificity for important toxins and threat agents. Antibodies for specific toxins such as: bacterial (botulinum, staphylococcal enterotoxins), protein synthesis inhibiting plant toxins (ricin), protein and peptide toxins of other biological origin (including pre- and postsynaptic neurotoxins, and membrane active substances), and other bacterial toxins such as clostridium prefringens toxin, are of particular interest. Physiologically active compounds of biological origin are also of interest as are anthrax, tularemia, Q-fever and human pathogens of Alphaviridae, Flaviviridae, Bunyaviriade, Filoviridae and Areaviridae.

PHASE I: Generate antibodies and demonstrate neutralizing specificity in a model system.

PHASE II: Produce research quantities of the specific humanized monoclonal antibodies.

POTENTIAL COMMERCIAL MARKET: Several militarily relevant toxins (e.g., Staphylococcal, botulinum toxin) present significant public health hazards through oral ingestion. No specific treatment regimen exists. Neutralizing monoclonal antibodies against these toxins would be a significant advance in protecting the public health.

A95-092TITLE:Design of Subunit Vaccines Inducing Cytotoxic T Cell Responses Against Infectious Disease Threats

CATEGORY: Exploratory Development

OBJECTIVE: Design and test subunit vaccines that induce protective cytotoxic T cell responses against infectious agents that infect or parasitize cells bearing MHC Class I molecules. Such vaccines will include specific peptide sequences derived from proteins produced by the pathogen and subsequently processed and expressed in the context of MHC Class I molecules by host cells. Such vaccines will be characterized by the induction of highly specific and functionally active T cell populations with the capacity to target infected cells and eliminate the pathogenic agent.

DESCRIPTION: Recently described techniques permit the elution and identification of specific short polypeptide sequences from MHC Class I molecules infected with pathogenic agents or transfected with genes from such agents. These peptides, in the context of Class I molecules, confer upon the immune system the ability to recognize and subsequently target cytotoxic T cells (CTL) to pathogen-infected cells with exquisite specificity. These techniques have been best defined using model systems for which CTL epitopes have been previously identified, but the approach holds great promise for a number of important infectious diseases such as malaria, denque and others where CTL mediated responses are known to be important to protective immunity. Under this solicitation, peptide sequences representing potential epitopes to be included in a CTL vaccine will be identified and evaluated.

PHASE I: Demonstrate feasibility by preparing one or more cell lines of defined Class I type infected or transfected with a pathogen(s) or specific genes from a selected pathogen(s). Identify critical peptides associated with these Class I molecules to include determination of sequence and the ability of such peptides to sensitize target sells for CTL mediated killing.

PHASE II: Engineer one or more subunit vaccine using synthetic peptide or recombinant expression technology incorporating such epitopes and demonstrate protection in a suitable model system.

POTENTIAL COMMERCIAL MARKET: Vaccines that induce protective CTL responses are likely to be required for such major infectious diseases as HIV, influenza, malaria, dengue and others. The commercial potential of efficacious vaccines against these diseases is enormous.

A95-093TITLE:Identification of Mosquito Attractants Produced by Humans

CATEGORY: Basic Research

OBJECTIVE: Develop a new category of mosquito repellents by masking/blocking volatile attractants produced by humans.

DESCRIPTION: Diethylmethylbenazmide (deet) is the active ingredient in almost all commercial and military arthropod repellents. Deet was discovered in a random survey of compounds for repellency. Attempts to improve the efficacy of deet by modifying the chemical structure have not been successful. Problems associated with deet include a lack of broad spectrum efficacy, odor, solvent properties, limited duration and low user acceptability. Concerns about deet's effects on health have resulted in use restrictions in California and New York. A more effective, safe and acceptable repellent is needed for military and civilian use.

PHASE I: Phase I would consist of: 1) a literature search to identify the human/animal volatile mosquito attractants identified to date, and 2) studies to identify individuals highly attractive and unattractive/repellent to host-seeking mosquitoes. Anecdotal reports, and field experience by WRAIR entomologists, clearly identify some individuals as more attractant/repellent to mosquitoes. This observation requires validation. Individuals highly

attractive and unattractive/repellent to mosquitoes could be identified, and the response quantified, using modified olfactometers and laboratory reared mosquitoes.

PHASE II: Phase II would involve trapping, quantifying and identifying human/ animal volatile materials responsible for mosquito attractancy/repellency. This study could be conducted using low-temperature vapor traps, a multi-port mosquito olfactometer and highly sensitive analytic methods (e.g., gas chromatography-mass spectroscopy) to identify the chemical structure of the mosquito attractants/repellents produced by humans. Once characterized these materials could be labeled and used in studies to identify the corresponding receptor on the mosquito.

Phase III: Phase III would involve synthesis and evaluation of masking or repellent compounds based on the tertiary structure of the natural attractant/ repellent or mosquito receptor.

POTENTIAL COMMERCIAL MARKET: Development of a new generation of insect repellents based on masking/blocking the mosquito attractant could greatly reduce mosquito transmitted diseases, for many of which there are no licensed vaccines and parasite drug resistance is widespread. There also would be a large commercial market for a more effective repellent against nuisance mosquitoes.

A95-094TITLE:Development of Lightweight, Portable, Minimally-Invasive Physiologic Sensors for the Multi-site Determination and/or Quantitation

CATEGORY: Exploratory Development

OBJECTIVE: To minimally-invasively measure (at multiple sites) the systemic concentrations of diagnostic proteins associated with traumatic injury. 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 damage, metabolism and prognosis 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.

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.

A95-095TITLE:Medical Decision Algorithm for Pre-Hospital Trauma Care

CATEGORY: Engineering Development

OBJECTIVE: To develop computer algorithm(s), capable of accepting data from physiological sensors already under development, which will operate in small, hand-held personal computers such as the Soldier Individual Computer, 21st Century Land Warrior (adapted for medical applications).

DESCRIPTION: This decision algorithm must be capable of accepting multiple inputs, (such as tissue pH, tissue 02, tissue blood flow, cardiac output, heart rate, ambient temperature, and body temperature), and provide output in 15 seconds or less. Output would be a combination of "likely survival" and " approximate survival time", which could each be digitally displayed, but must be displayed as RED, AMBER, GREEN (RED=death imminent; physiological and physical parameters 20% of "normal"; AMBER=serious to extraordinary deviation from normal physiology--death

likely in 30-60 minutes; physiological and physical parameters 50% of "normal"; GREEN=survival likely; physiological and physical parameters within 80-100% of "normal".)

PHASE I: Develop realistic algorithms based on scientific literature values, previous models and validated assumptions, including descriptions above.

PHASE II: Validate algorithm with experimental data; refine algorithm, compile algorithm and necessary supporting software, drivers, etc. for incorporation on microprocessor chip. Phase II model must be capable of updating data from previous readings, in order to determine whether intervening treatment was effective, or whether spontaneous course of casualty is changing.

POTENTIAL COMMERCIAL MARKET: Exclusive of the U.S. military medical applications, the commercial market is enormous. Potentially, this device could be used on every vehicle responding to emergencies and by every paramedic, as well as for triage by qualified medical personnel.

A95-096TITLE:Stable Biodegradable Polymers for Delivery of both Polar and Nonpolar Drugs

CATEGORY: Exploratory Development

OBJECTIVE: To develop stable biodegradable polymers or other biodegradable excipients that will effectively and safely sustain-release anesthetic/analgesic drugs at therapeutic yet nontoxic levels over a prolonged period of time. The excipients must allow for the delivery of both polar and nonpolar drugs or compounds.

DESCRIPTION: Pain following traumatic injury is universal, but dramatically increases in frequency during war. Presently used anesthetics, though effective, require repeated administration and are plagued by dose control problems and unwanted side effects. Sustained-release formulations of select local analgesic/ anesthetics need to be developed, which will provide prolonged (days to weeks) pain relief, while reducing debilitating side effects. Preliminary work using novel drug delivery systems has shown that a drug's anesthetic effect can be sustained while its toxic effect can be greatly reduced or eliminated. This advantage will likely result in salvage of effective anesthetics now shelved due to their toxicity. Furthermore, the promise of using drugs that provide selective anesthesia (pain control without loss of motor function) may become a reality when such delivery systems are employed. Such advancements in pain control offer tremendous advantages for use in military evacuation scenarios and would have broad applications in civilian medicine.

PHASE I: Develop new or modified polymers for delivery of both polar and nonpolar drugs (specifically anesthetic drugs) that could be safely injected intravenously, intrathecally and into soft-tissue.

PHASE II: Incorporate polar and nonpolar drugs or compounds (specifically anesthetic drugs) into the polymers so that they sustain-release drugs as they biodegrade. Perform preclinical trials to test efficacy for pain control.

POTENTIAL COMMERCIAL MARKET: Development of sustained-release formulations of conventional and novel anesthetics/analgesics will potentially allow long-lasting anesthesia following single dose therapy. Such a capability will minimize wounded soldier decrements and the burden on medical support resources. Improved methods to control pain, acute and chronic, will also have a major impact on major medical, psycosocial, and economic problems of society at large.

A95-097TITLE:Computer Model of Red Blood Cell Chemistry

CATEGORY: Engineering Development

OBJECTIVE: To develop an exact working model of red blood cell chemistry to aid in the design of improved blood storage solutions

DESCRIPTION: A preliminary model already exists, and should be used as the point of departure in the current refinement and development of the red cell chemistry model. The original model was developed by the RAND Corp (1950's & 1960's), and was refined by UCLA School of Medicine--called "Fluid Mod". The original model, a

mathematical engine, solves a very large number of pre-steady state, steady state and equilibrium equations. The model to be developed must exactly describe hemoglobin chain interactions and their interaction with hydrogen ion, other metabolic inputs such as metabolite concentrations, pH, etc. in another program and pass them to the original "engine", which then solves all of the equations. The new model must use molar, rather than molal concentrations.

PHASE I: The objective in Phase I would be to re-write the original model from the original (and awkward) Fortran to C++, and interface the model to a windows environment on common microcomputers, with adjustment of the parameters to those needed for the calculations from the usual molar physical units used in either physiology or biochemistry.

PHASE II: The objective of Phase II would be to extend the work completed in Phase I to include a general chemistry program as well as all of the red cell functions, hemoglobin chemistry included.

POTENTIAL COMMERCIAL MARKET: Completion of the Phase I objective, using "Fluid Mod", will have widespread interest in medical schools for teaching electrolyte therapy in the emergency room, etc. The results of Phase II will have a broad appeal to students and researchers doing kinetics and thermodynamics of biological or purely chemical systems. Thus, the potential Contractor must show knowledge of how to bring the programs to market.

A95-098TITLE:Advanced System for Worldwide Surveillance of Rickettsial Disease Antibodies

CATEGORY: Advanced Development

OBJECTIVE: Develop, laboratory validate, and field test a system for surveillance of rickettsial diseases on a worldwide basis. The successful product will be customized for geographic regions and simple enough to use reliably in central diagnostic facilities of developing nations.

DESCRIPTION: Rickettsial diseases like epidemic typhus and scrub typhus have had major impact on armies in endemic areas for hundreds of years. Although curative antibiotics are available, an infected soldier is likely to be out of action for some days before diagnosis and for days for weeks after treatment. Currently, we have very little information on risk of these diseases within any given geographic region because the current tools for diagnosis are either inaccurate (Well-Felix test) or cumbersome (indirect immunoflourescence assay). Specific examples of our poor knowledge of risk of these diseases include an outbreak of spotted fever attacking two-thirds of U.S. forces deployed to Botswana, the discrepancy between some 800 cases of scrub typus reported annually from Thailand compared to the estimated actual incidence of 20,000 cases per year, and the discovery this year of a new ehrlichial pathogen in Wisconsin. In a recent meeting sponsored by the World Health Organization, the great need for a program of surveillance was acknowledged, but current diagnostic tools were considered too difficult to standardize in many laboratories. A new diagnostic approach should satisfy the following criteria: 1) Simplicity: Accurate use should require minimal training; 2) Speed: One technician should be able to complete 30 serum samples in one day; 3) Accuracy: Specificity and sensitivity compared to indirect immunofluorescence assay should produce results which give at least a relative indication of the amount of antibody reacting with each antigen; 5) Minimum equipment requirement: The assay should not require expensive equipment, such as a fluorescence microscope or a spectrophotometer; 6) Easy shipment: Reagents should be stable enough to allow shipment at temperatures which do not need to be lower than $4^{o}C$; 7) Broad applicability; Versions of the test system should be capable of measuring antibody to the major know rickettsial (typhus group, scrub typhus group, and spotted fever group) and ehrlichial (chaffeensis type and sennetsu type), as well as Q fever; and 8) Controls: Each test will include appropriate negative and positive controls to assure that conditions for each test are correct.

PHASE I: The initial effort will require optimization of the components of the assay in the laboratory, using known sera. The various components will be assembled into regional packages (e.g., typhus; spotted fever, scrub typhus, Q fever, and sennetsu in Southeast Asia) with a "user friendly" format that provides complete kits and instructions.

PHASE II: Field validation will consist of distribution of the kits to collaborating countries with the intention of collecting 30 representative sear in each country each month. Experience from this effort will establish whether the assay system requires modification.

POTENTIAL COMMERCIAL MARKET: A successful test system would serve two different international markets. First, the system could be sold to individual governments and world health organizations for the purpose of

continuing surveillance. Second, the system could be used for individual patient diagnosis where the diseases are found to be prevalent.

A95-099TITLE:Model the Interface Between a Respirator and the Human Face

CATEGORY: Basic Research

OBJECTIVE: Develop graphical and mathematical models of the M40 protective mask, the human face, and the interrelationship between protective mask and face when the mask is worn. Develop predictive techniques for estimating the levels of comfort and protection provided by a mask prior to fabrication of prototypes.

DESCRIPTION: Each time a new program is initiated for a protective mask, large numbers of volunteers are required to verify the fit and comfort. Models do not presently exist of the human face and the protective mask and techniques for analyzing their interaction when the mask is worn do not exist. If these models can be developed, designers would be able to use their computer to analyze the impact of changes to the design quickly and easily. Final designs would still have to be verified with large samples of real persons, but changes could be quickly analyzed. The net result would be a reduction in the time required to develop and test new masks. The techniques developed for creating the models would apply not only to military respirators but to respirators worn by firefighters, scuba divers, and hazardous materials handlers.

PHASE I: Conduct literature reviews to identify existing models of the interrelationship of the face with masks or other items of clothing or equipment worn. Identify relevant portions of models that are of use in this effort. Develop mathematical and graphical models (suitable for AutoCad for example) of mask, face, and interrelationship.

PHASE II: Develop predictive techniques for determining the relative levels of comfort and protection provided by prototype masks prior to fabrication of prototypes.

POTENTIAL COMMERCIAL MARKET: The techniques developed for modelling the face and respirator would be valuable to developers of commercial respirators for scuba divers and for fire fighters. They would be able to test prototype designs of respirators on the computer rather than requiring large samples of people each time a change occurs.

A95-100TITLE:Remote Measurement of Atmospheric Temperature and Moisture

CATEGORY: Exploratory Development

OBJECTIVE: Remotely measure more accurate profiles of atmospheric temperature and moisture in near real-time. A suggested approach would be development of a tuneable microwave radiometer for sensing temperature and atmospheric moisture using oxygen and water lines in the atmosphere. The resulting system should be compact and lightweight and should be able to rapidly and precisely select a large number of both water and oxygen frequencies under software control and accurately measure the corresponding brightness temperatures.

DESCRIPTION: Accurate first-round fire-for-effect artillery requires timely knowledge of the meteorological parameters of the atmosphere along the trajectory of the round. Systems relying on balloons are inherently slow and impose a large logistical burden. Our best current radiometric sensing technology still relies on a two-point non-tuneable technology for sensing atmospheric water. More frequencies, under precise software control, should permit improved accuracy.

PHASE I: Design a compact, portable, and precisely tuneable water vapor radiometer with at least 100 frequency channels distributed in the 18-23 GHz range and the 30-40 GHz range. All channels should be selectable under software control and should be measured to 0.2 K or better. Channel centers should be selectable within 1 MHz or less.

PHASE II: construct a working prototype of the Phase I design, including a laptop computer control system and software to retrieve atmospheric liquid water and water vapor overburdens, and demonstrate features and performance with simultaneous, co-located radiosonde measurements.

POTENTIAL COMMERCIAL MARKET: Atmospheric temperature and moisture are key parameters for almost every aspect of weather and atmospheric environment. A compact, automated, real-time temperature and moisture sensor should find many applications in general meteorology, aviation support, and agricultural planning and climate studies, replacing the radiosonde for many applications and going places where it would be inconvenient to maintain a crew to launch radiosondes. In addition, the moisture measurements at which such an instrument excels would be valuable for determining phase-lags due to the atmosphere which impact geodesy and radio astronomy.

A95-101TITLE:Cost Effective Flue Gas Cleaning via Irradiation with Fast Electrons, Electron Beam Dry Scrubbing Process (EBDS)

CATEGORY: Exploratory Development

OBJECTIVE: Develop stable EBDS techniques which can be used to remove Sulfer Dioxide (SO2), Nitrous Oxides (NOx) and other contaminates from flue gas. The thrust of the research will be design and development of devices to produce to provide suitable electron beams in a cost effective manner.

DESCRIPTION: A great deal of concern globally has focused recently on the effects of smoke stack emissions, particularly acid rain from fossil fuel power plants. For example, German legislation requires removal of SO2 and NOx from flue gas emissions at nearly all power plants. The German Institute of Thermal Turbomachinery has studied the optimization of removal efficiency and energy consumption at its facility for emissions scrubbing via the electron beam process. In the US, EBARA Environmental Corporation has produced a pilot plant in Indianapolis based on the EBDS. In both cases the irradiation of the flue gases produces active radicals and atoms which react with SO2 and NOx to form their respective acids. In the presence of ammonia (NH3) these acids are converted to ammonium sulfate and ammonium sulfate-nitrate, i.e. useful fertilizer. It is desired that technology developed at the Department of Defense (DOD) and contractor organizations focusing on electron beam production for military purposes, such as flash X-ray machines, be adapted to resolution of problems inherent in scaling the EBDS technique to smaller applications. Such applications include pollution remediation where source power and size are highly constraining factors. Most engineering work to date has focused on large power plants. This topic focuses on cost-effective, compact e-beam production for cleaning-up fossil fuel emissions from maritime vessels, tractor trailers, locomotives, small power plants, refuse incinerators and a host of other small contributors to atmospheric SO2 and NOx. The Army is interested in production of compact, high power sources and microwave generators that can produce relativistic electron beams for military purposes. As an example, the " Super-Reltron" microwave tube is a very efficient, high power radio frequency source representative of a technology which might be coupled with LINAC technology to produce the high average power, relativistic e-beams necessary for the EBDS process. It would be beneficial if the DoD's heavy manpower investment in e-beam technology could be transferred to the civilian economy. Proposals should not be limited to the LINAC approach. Electron beam energy and current may be chosen around the parameters dictated by efficient operation of the EBDS process.

PHASE I: Develop theoretical model of a cost effective e-beam source for use in EBDS process. Perform a theoretical analysis determining relationship between cost and scaling.

PHASE II: Construct a working prototype of the most suitable method indicated by Phase I.

POTENTIAL COMMERCIAL MARKET: A compact EBDS technology would be of inestimable value in both developing and already industrialized nations. Recent international agreements have committed countries to setting and enforcing clean air standards. The US is a world leader in the evolving environmental technologies business; transfer of DoD know-how into this rapidly growing sector of our economy promises to both strengthen our economic stake in an expanding competitive market, while further bolstering the prestige and image of the Army Research Laboratory as a leader in this area.

A95-102TITLE:Portable Laser Induced Breakdown Spectroscopy Sensor for Toxic Metal Analysis

CATEGORY: Exploratory Development

OBJECTIVE: Development of a portable sensor, based on LIBS technology, for the detection of toxic metal contamination

DESCRIPTION: A specific need exists for portable sensors that are capable of real-time, high-sensitivity analysis of the toxic metal contaminant Sb, As Be, Cd, Cr, Co, Pb, Mn, Hg, Ni, Se, and TI. Sites of interest on Army installations include structures, firing ranges, soils, and waters. Sensitivity and specificity to this wide range of metals poses a major technological challenge. A particular advantage of a portable system for real-time trace metal analysis would be the saving of considerable time and cost since, at present, samples must be acquired from sites of suspected contamination and then sent to off-site laboratories for subsequent analysis. The spectrochemical technique known as Laser Induced Breakdown Spectroscopy (LIBS) is considered to have potential for toxic detection in a wide variety of environments. The LIBS technique utilizes a pulsed laser to produce a plasma in gases, aerosols, particulates, liquids, and solids. The hot plasma is the source of a characteristic wavelength emission for each constituent metal. A number of examples of successful laboratory demonstration of the LIBS technique for metal detection have been published. What has been impeding the development of this promising technique into a commercial product for field use is the requirement of an affordable and reasonably compact laser source for the necessary high energy, high peak power laser pulse. However, improvements in laser design have led to simplicity of operation, reliability, compactness, ruggedness, and reasonable cost. Coupled with the development of small detectors capable of multispectral detection and fiber optic signal delivery systems, these recent advances suggest that the time is right for the development of a portable LIBS system for field use.

PHASE I: The Phase I work would develop, and deliver to the Army, a simple first-generation LIBS system prototype capable of detecting Pb in firing ranges as well as in paint contained in various types of military buildings. The requirements for this prototype include hand-held operation and laser beam delivery via an optical fiber wand. This sensor will have to detect Pb concentrations in the ppm range and be interference free.

PHASE II: In Phase II, a second-generation multi-element prototype LIBS sensor would be developed and delivered to the Army. For this unit, optimal laser wavelength over the near-IR to UV spectral range and the optimal detector configurations between array detectors and acousto-optic tunable filters would be determined. This prototype would be capable of detecting all of the metals listed above, deploy an advanced chemometric system for rapid and specific analyte determination, and have an operating life greater than 500 hours before service.

POTENTIAL COMMERCIAL MARKET: There is an acute need for the characterization of sites of environmental contamination, both military and civilian. Therefore, the worldwide commercial market for portable sensors for toxic metal environmental contamination is significant. This technology would also be useful in the monitoring of toxic metal release during waste combustion.

A95-103TITLE:Computational Fluid Dynamics of Complex Three-Dimensional Multiphase Flowfields

CATEGORY: Exploratory Development

OBJECTIVE: The objective of this effort is directed towards developing aerosol and vapor phase chemical/biological agent concentrations, complex flow patterns, and in-situ destruction (reaction, bulk break-up or agglomeration) due to shock, aerodynamic pressure, temperature, and chemical reactions in enclosed structures and at the exhaust ventilation openings or under high kinetic energy conditions from a missile impact. The model shall provide a predictive capability of potential collateral toxic effects from the release of chemical and biological agent materials.

DESCRIPTION: The requirements for counter-proliferation and theater missile defense has necessitated the development of a productive mass transport model of hazardous materials related to post engagement events for the neutralization of chemical and biological agent production and storage facilities or a missile-to-missile intercept. The mass transport model shall be employed to minimize the potential collateral toxic effects from the release of chemical and biological agent materials in the facility and the surrounding environment.

PHASE I: Develop the framework for an ab initio computational model to predict the in-situ destruction and the diffusion and convective mass transport characteristics of solid phase and/or liquid phase particulate material and vapor phase material in an enclosed environment employing air handling systems or an open atmosphere environment as in missile-to-missile intercept scenario. The framework shall include, but not be limited to, numerics (3D finite-volume discretization; fully implicit source terms; boundary conditions), grid features (dynamic gridding, grid patching of complex geometries, solution-adaptive gridding), thermochemistry, multiphase flowfields, mass transfer, heat transfer, and turbulence.

PHASE II: Continue improvements on an ab initio computational model to predict the in-situ destruction and the diffusion and convective mass transport characteristics of solid phase and/or liquid phase particulate material and vapor phase material in an enclosed environment employing air handling systems. Additionally, the proposed model shall be validated by comparing the executed code output to the available test data under diversified initial input conditions.

POTENTIAL COMMERCIAL MARKET: For use as a hazard prediction tool in chemical and biological processing production facilities. Additional use in the improved design of air handling systems and air filtration systems in hospitals or high security areas to mitigate transport of infectious diseases or toxins.

A95-104TITLE:Rapid Ammunition Barricade Technology

CATEGORY: Exploratory Development

OBJECTIVE: Develop a rapid, low cost, technology to build substantial barricades in remote areas which does not require heavy construction equipment or significant labor resources and uses construction materials of minimal or negligible weight and volume.

DESCRIPTION: The shift in U.S. national military strategy from forward deployed forces to continental U.S. based forces has intensified the need to develop a technology for the building of quick and inexpensive barricades to protect troops and supplies from enemy attack during early entry operations. In addition to providing protection from enemy fire, these barricades are needed to prevent explosive propagation between vulnerable ammunition stacks. Without barricade protection, explosive propagation could result in the loss of substantial ammunition supplies. Recent studies have highlighted the critical and vital strategic importance of protecting these ammunition supplies during early entry operations. Troops and supplies for early entry operations are typically inserted using Air Force cargo aircraft. The ability to transport heavy equipment and building materials for barricade construction is nearly non -existent, due to the need to transport higher priority supplies such as weapons, vehicles, and ammunition.

The U.S. Army's growing involvement in operations other than war, such as flood control and hurricane relief, has also created an increased need for the development of technologies to rapidly build barricades. During these emergency operations, the typical method used to control flooding is to build sandbag walls. This is very labor intensive and time consuming. An improved method to build barricades would substantially enhance the Army's effectiveness during these operations.

To effectively prevent ballistic penetration and explosive propagation, the barricades developed must have substantial weight and density, such as that provided by water or soil. To reduce the amount of material which has to be air transported, the technology developed to build barricades should make maximum use of locally available resources such as water, soil, or sand, to comprise the barricade's bulk. The construction method should make maximum use of readily available lightweight Army equipment such as generators and pumps. Typical dimensions for these barricades is 3 - 6 feet wide, 6-12 feet high, and approximately 20 feet long, however this may be flexible. Examples of technologies which might be considered include expandable water filled bladders, phase change and lightweight, and high strength materials.

PHASE I: Investigate new and innovative technologies for the field construction of rapid barricades. Conduct initial testing to determine if critical design requirements, such as stability, strength, and speed of construction are achievable. Conduct marketing survey to determine commercial potential.

PHASE II: Design and develop full scale prototypes of a rapid barricade. Perform full scale operational and technical testing to determine if the technology developed meets all requirements and is acceptable to potential military users.

POTENTIAL COMMERCIAL MARKET: The technology developed under this program can be utilized in a variety of commercial applications. It can be used for environmental restoration projects, erosion control, flood control, earth embankment revetments, highway sound barriers, barricades to stop rocks and boulders from falling on highways, and to control the dangers of blasting during civilian construction projects.

Cost Reduction: The ability to construct barricades without heavy equipment and with greatly decreased labor resources will provide substantial cost and labor reductions. This technology leveraging will allow a future smaller force to perform work which previously required many troops and expensive heavy equipment. This cost savings will be realized during future flood control, early entry, and medium regional conflicts.

A95-105TITLE:Novel Lightweight Desalination Systems for Drinking Water

CATEGORY: Exploratory Development

OBJECTIVE: To develop a small lightweight, handheld, manual device for the individual soldier to desalt seawater for drinking.

DESCRIPTION: The device to be designed will be capable of removing pathogens, suspended materials and dissolved solids from fresh, brackish and salt water to provide one liter of drinking water per day for the individual soldier. The unit must be capable of being transported and operated by one person.

PHASE I: The Phase I program would consist of surveying the present and new technologies and conducting preliminary tests to select a technique for further development. Sub-systems would be selected and laboratory tested ending with a breadboard to prove feasibility.

PHASE II: During Phase II, the selected technology would be developed into a working system by designing, building and testing a prototype. The prototype must produce water that meets the water quality standards for drinking water and meet the military requirements for human factors, safety, and maintenance.

POTENTIAL COMMERCIAL MARKET: Lightweight desalination systems would have commercial application for providing safe drinking water for leisure activities as well as survival in emergency situations as in life rafts and small boats.

A95-106TITLE:Real-Time Monitoring System for Trace Chemical Vapors During Open Burning/Open Detonation (OB/OD)

CATEGORY: Exploratory Development

OBJECTIVE: To develop a real-time monitoring system for trace chemical vapors that may be emitted from OB/OD of energetic materials.

DESCRIPTION: OB/OD provided a primary means of destroying or treating waste munitions. Although historical records indicate these to be safe and efficient methods, increased environmental awareness is generating data requirements which exceed the capabilities of current data collection technology. An example is the need for data to support permits submitted under provisions of the Resource Conservation and Recovery Act (RCRA) (Subpart X). Many prime target analyses requires detection at the parts-per-billion level, or lower. To acquire and provide this data in an efficient manner, technology needs to be developed that can provide for monitoring of trace chemical vapors at the part-per-trillion level in real-time.

PHASE I: Identify appropriate existing chemical or physical sensing mechanisms. Develop methodology for design implementation and evaluation of prototype system.

PHASE II: Build the prototype system. The prototype system will be tested at the U.S. Army Dugway Proving Ground Propellent, Explosive, Pyrotechnic Thermal Treatment Evaluation and Test Facility.

POTENTIAL COMMERCIAL MARKET: In addition to the RCRA applications, which apply to both private and public sectors, this technology has great utility in the work place and hazardous waste sites for monitoring of hazardous vapors. It could also be used in airports and cargo holds of ships for monitoring of explosives and narcotics.

A95-107TITLE:Microwave Applicator for Paint Stripping

CATEGORY: Engineering Development

OBJECTIVE: The objective is to develop a microwave applicator device which will provide concentrated energy to strip paint from composites, wood, and steel substrates. This system should be portable and operate safely during the removal of paint. The structures from which paint needs to be removed include helicopters, aircraft, ships, buildings and bridges.

DESCRIPTION: In the paint stripping processes, by blasting and chemical stripping, hazardous dust and chemicals are produced. Microwave energy can be used with or without a susceptor material to heat the organic paint in order for the paint to be stripped easily. Susceptor materials interact with the microwaves and can reduce the heating time required to strip the paint.

PHASE I: Develop the design concepts necessary to produce concentrated microwave energy at the paint interface. Safety switches and sensors should be used so that the device is safe to operate in the presence of workers and occupants. Design criteria should include the use of susceptor materials if they are needed.

PHASE II: Develop a prototype microwave applicator device. Field test the device on aircraft composites, and wooden structures.

POTENTIAL COMMERCIAL MARKET: Should a reliable and safe microwave applicator be developed, many aircraft and buildings can use this device for paint removal. A very large market exists for a proven paint stripping system which is simple to operate.

A95-108TITLE:Topographic Technology Enhancement

CATEGORY: Exploratory Development

OBJECTIVE: Research and establish procedures, review existing and potential standards and data resources, and determine average time for throughput in the creation of a standardized value-added data set that links to Defense Mapping Agency (DMA) VPF-based, very large scale vector map product, VMap 3 (aka UVMap). Develop case study for these procedures and evaluate feasibility.

DESCRIPTION: Studies have shown that there is a target audience in need of very highly detailed feature data sets, particularly in the urban environment. This audience will increase significantly as Army moves forward with digitization (Force 21), right-sizing, and Force Projection plans. This project would determine the baseline SOP's production requirements and quality control methodologies necessary for Army facilities to generate value-added feature and attribute coverages to overlay DMA's standard urban vector map product, VMap 3. Value-added coverages would have to be compatible with Topographic Engineering Center developed software that perform statistical checks on data completeness, and would have to be acceptable to DMA and Army by adhering to established standards as well as map coverage and data storage requirements. Concurrently, the coverages must maintain the look and feel of the VMap3 product and other products commonly used by Army in battlefield environments.

PHASE I: Research completeness of VMAP3 prototype, Army SOF and M&S requirements for very highly detailed data, map production requirements in Army facilities, data resources available for value-adding use, and DMA's standards; from these efforts, establish implementation plan for value-added concept, selecting a feasible case study site for which VMap3 or comparable alternative is available

PHASE II: Perform and monitor case study, creating value-adding coverages in mock situation of choice (either standard or crisis production scheme). Assess coverages' quality, suitability for Army and civil use, and adherence to VPF and production standards. perform post-study evaluation of concept and make recommendations for improvements and implementation in Army Force 21 environment.

POTENTIAL COMMERCIAL MARKET: The ability to provide information to standard mapping products has potential in both Army and civilian uses, to include simulation of urban combat, mission planning and rehearsal, training for urban evacuation procedures, natural disaster preparedness, and civil unrest control.

A95-109TITLE:A Time-Dependent Non-Linear Free-Surface Wave Simulator for Military Applications

CATEGORY: Exploratory Development

OBJECTIVE: To develop and demonstrate a three-dimensional (3-D) water surface, time-series model of a high-order of accuracy that would allow determination of the complex hydrodynamics of nearshore waves for navigation, vessel control, mooring dynamics, harbor tranquility, and tracking of free or loosely- tethered objects.

DESCRIPTION: Effects of boundaries and bottom topography on gravity waves in deep water are minimal and, thus, idealized and simple frequency-domain or spectral wave models may be used to characterize design conditions. In the nearshore region where the Army has a military interest, time-dependent wave models are necessary since nonlinear processes nearshore strongly influence the propagation of waves. Accurate and realistic wave simulation may be obtained with time-dependent models if nonlinearities are included. The Green-Naghdi (GN), Boussinesq, and Volume of Fluid (VOF) theories are particularly well-suited to nonlinear shallow-water wave modeling, although the GN approach is not subject to the limitations other wave theories have in depths less than five wavelengths. With user-friendly interfaces, a model built from one of these theories would allow field commanders to obtain accurate wave estimates necessary to plan and schedule military and civil operations. The general availability of this technology would enhance decision making of leaders, resulting in safer and more efficient operations such as amphibious landings, harbor design, vessel safety and maneuvering in mine-restricted waters, ship mooring and berthing, mine tracking, dredging, and surface-drifting oil spills.

PHASE I: Investigate the suitability of the three above mentioned time-dependent, nonlinear water wave theories for developing a new 3-D shallow-water wave simulation system. Incorporate important nonlinear processes. Design a flexible wave simulation system that allows time-dependent input/output and post -processing. Develop a base model and demonstrate the features on the system using environmental and climatology data at Camp Pendelton and Camp LeJeune (used for amphibious exercises).

PHASE II: Extend the theory and numerics of the military wave simulator developed and tested in Phase I to the prediction of wave effects inside harbors for evaluating mooring and berthing of ships, and for particle tracking of the floating or free- moving objects at the surface of the sea. Incorporate wave breaking, diffraction from surface-piercing structures, and wave- current interaction. Integrate with a graphical user interface (GUI) to facilitate its use by military commanders and others no expert in ocean sciences.

POTENTIAL COMMERCIAL MARKET: The technology will be versatile and my be directly used in several commercial applications such as planning and prediction of wave climatology by the port and harbor authorities responsible for commercial shipping, trafficking, and safety of maritime vessels, and on- and off-loading of the cargo ships offshore and in the ports; contingency planning, remedial and cleanup, of oil spill operations by private companies, Federal and state agencies in open sea or near coastlines; and dredging and construction in the coastal waters by the military and civilians.

A95-110TITLE:Geographical Information System (GIS) for Marine Operations

CATEGORY: Advanced Development

OBJECTIVE: To develop a PC-based GIS that will provide environmental information to assist in planning and scheduling coastal marine operations such as Logistics Over The Shore (LOTS), dredging, oil spill cleanup or construction projects exposed to the wave environment. The system will include both forecasted and historical environmental information presented in a graphical user interface (GUI) which can by used by personnel who are not experts in coastal engineering.

DESCRIPTION: A comprehensive set of coastal environmental data is a requirement in planning and scheduling any coastal marine operation. A methodology for " Real-Time Forecasting" (RTF) is needed to allow field commanders to predict wave conditions at a site and to evaluate historical data. The RTF will provide considerable enhancements to the existing knowledge and will provide more informed decision making and result in safer, more efficient operations. Historical databases will include information on beach characteristics, weather, water waves, currents, and water levels. Forecast information will include winds, waves and water levels. The system will include numerical modeling of waves, water levels, and currents. All information will have a geographic reference and will be presented on a "digital nautical chart."

PHASE I: Evaluate the capabilities of current hardware and software related to project needs. Determine all data sources required. Design basic structure of the system including presentation methods based on consultations with the user community.

PHASE II: Develop a GIS to be displayed on a digital nautical chart, including acquisition of hardware and software, and system integration. Included during this phase will be testing and demonstration of the system during military and commercial marine operations.

POTENTIAL COMMERCIAL MARKET: The information system developed will be used by the DOD in LOTS and amphibious operations and by private companies responsible for dredging, oil spill management, share stabilization engineering, and construction in coastal areas.

A95-111TITLE:Diagnostics System for Antenna Drive Motors and Bearings

CATEGORY: Exploratory Development

OBJECTIVE: To design and test a system to allow for early diagnostics of antenna drive system and associated bearing wear problems.

DESCRIPTION: ALTAIR's drive system consists of five 150 hp DC motors which are coupled to the drive pinions in both azimuth and elevation through Falk reduction gear boxes. The antenna rides on 16 wheels, mounted in four pivoting wheel "bogies". Including the elevation axis bearings and the pintle bearing, there are 59 major bearings. Noise and/or vibration data can be taken to generate a frequency spectrum signature for the gear boxes and the bearings. Changes in the spectrum could flag potential problems before a failure occurs.

PHASE I: Investigate best methods for generating frequency spectrum signature of drive components. Contribution of lube pump and air blower noise and vibration must be determined as filtering may be required. Install sensors and take data for evaluation purposes. Determine the types of degradation's and failures that can be detected by analyzing the spectral signatures of the drive components.

PHASE II: Install vibration sensors on all drive components and bearing locations and route through multiplexed for selective monitoring at the antenna console. Generate characteristic signatures for each component and establish historical data base.

POTENTIAL COMMERCIAL MARKET: Additional markets could include other DoD Spacetrack radar sites, air traffic control radars, weather radars, or other sensors that operate on a 24 hour per day basis and can not be easily monitored for hardware degradation. The techniques developed could be adapted to provide realtime diagnostics for large structures, such as bridges.

A95-112TITLE:Low-Cost Mission Intensity Analyzer

CATEGORY: Exploratory Development

OBJECTIVE: Develop a low-cost mission intensity analyzer for military air and ground vehicles which correlates actual vehicle usage with component damage rates to enable savings through rational timing of maintenance operations and component replacement.

DESCRIPTION: Maintenance service intervals are typically based on assumed extreme operating conditions. Determination of actual operating conditions will enable component specific servicing or replacement on an as-needed basis. The costliest and least reliable part of structural usage monitoring systems in military vehicles is the integration of instrumentation required to determine loads. Using GPS and other self-contained sensors, it is possible to develop a stand-alone system of sufficient precision to describe various mission segments and quantify structural usage in terms of effective usage hours or miles. This project will demonstrate that the necessary logic and hardware can be implemented at a cost near $3000 using commercial digital electronics.

PHASE I: In this phase a system will be developed and tested for vehicles which operate with virtually full trajectory alignment (vehicles with zero transverse velocities). This condition holds true for ground vehicles and fixed wing aircraft under most conditions. The structural usage logic will be based on reports of ongoing work in the Army Research Laboratory's (ARL) Vehicle Structures Directorate (VSD) and is limited to one structural part (wing box or chassis). Demonstration of the concept can be performed either on a ground vehicle or a light aircraft and should be capable od discerning between conservative and abusive operation.

PHASE II: Phase II will extend logic to include vehicles whose alignment is not necessarily aligned with trajectory; specifically addressing the situation encountered with helicopters. These systems must have the computational capacity to assess usage for up to 20 parts or subsystems. In this more mature system, self-diagnostics and fail-safe features are desired. The emphasis will be on low cost implementation. Again, most logic will be derived from reports of ongoing work in the ARL VSD.

POTENTIAL COMMERCIAL MARKET: Commercial helicopters, trucks, and trains can all benefit from an affordable mission analyzer that bases maintenance intervals on actual usage instead of predetermined values.

A95-113TITLE:Navier-Stokes Computational Fluid Dynamics Methodology for Dynamic Stall Calculations

CATEGORY: Exploratory Development

OBJECTIVE: Develop, validate, and demonstrate a three-dimensional, time- dependent, compressible Navier-Stokes computational fluid dynamics code for prediction of dynamic stall on an oscillating wing at realistic Reynolds and Mach numbers typical of modern helicopter rotorblades. The model developed must utilize advanced turbulence and transition models, as well as dynamic adaptive gridding techniques necessary for the accurate prediction of dynamic stall.

DESCRIPTION: Dynamic stall on the rotorblades of modern helicopters is a major barrier to performance enhancement for these devices. Predicting the onset of dynamic stall requires the adequate spatial and temporal resolution of the erupting fluid during the incipient separation phase. Dynamic stall is often preceded by the occurrence of a leading edge shock, even at low freestream Mach numbers. The body of previous computations for this flow event shows the necessity for some type of dynamically adaptive grid methodology, to properly resolve the relevant flow features. To perform this type of calculation at realistic freestream Reynolds numbers, advanced transition and turbulence models must be used. In particular, the inclusion of a modern Reynolds-stress transport model is necessary, as a minimum. Development of such a prediction methodology would greatly help the Army in its quest for vibration reduction and performance improvement of modern rotorcraft.

PHASE I: A two-dimensional version of the code will be developed to prove the feasibility of the proposed grid adaptation scheme. This code should be validated by comparison with available two-dimensional experimental data for both the light and deep stall regimes. Investigation of innovative transition and turbulence modeling techniques will occur, although the actual implementation of these schemes may be made in Phase II (with the Phase I goal being the selection of a single candidate scheme).

PHASE II: The two-dimensional code will be expanded to consider full three-dimensional stall, with further refinement and implementation of the transition and turbulence models selected during Phase I. The resulting code will be validated and compared with existing two and three-dimensional dynamic stall data in both light and deep stall. At the conclusion of Phase II the code and a concise users manual will be delivered.

POTENTIAL COMMERCIAL MARKET: The reduction of dynamic stall-induced vibration inherent to modern rotorcraft is necessary if these devices are to become a viable part of the national transportation system. This computational methodology will be a key element in reducing these vibrations. In addition, a viable and validated

three-dimensional Navier-Stokes code capable of accurate and efficient prediction of unsteady separation will be of great use for a variety of commercial applications, including the commercial aerospace and automotive industries.

A95-114TITLE:Transmission of Information Through Helicopter Rotating Interface

CATEGORY: Exploratory Development

OBJECTIVE: To devise a means of reliably and affordably transmitting information to the rotating system of a helicopter from the fixed system and vice versa.

DESCRIPTION: Current methods of transmitting information through helicopter rotating interfaces are not as reliable as desired. Intermittent data dropout and noise are two of the problems which plague helicopter slip ring users. Poor electrical/physical contact and moisture or particle interference contribute to these problems. A means of transmitting information such as strain gage or pressure transducer voltages, actuator command signals or power signals to the helicopter rotor or to the fixed system as a return or feedback loop, is needed which will sustain a very high level of reliability under all types of conditions. This method must be implementable to a few aircraft or to many aircraft at a cost less than any currently available slip rings. Development of a low-cost, reliable information transmission system would support S&T Thrust #7, Technology for Affordability, as well as Structural Integrity Program objectives.

PHASE I: Select a basic design concept for feasibility study. This concept should allow for rapid transmission of multiple signals through the rotating interface. This effort should include demonstration of the concept and a preliminary design for further validation in Phase II. A final report and final briefing will be delivered to the Government at the Aviation Applied Technology Directorate at Fort Eustis, VA.

PHASE II: Develop a detailed design and fabricate a prototype system based on the selected design concept. Test the prototype system on a helicopter or a simulation platform similar to a helicopter for operational validation. Demonstrate transmission of various types of data through the rotating interface. Design should address protection from electromagnetic interference (EMI) and elements such as moisture and temperature extremes.

POTENTIAL COMMERCIAL MARKET: Considerable cost savings may be realized by introducing an improved, affordable method of information transmission through a rotating helicopter interface. Quality of data and cost of data acquisition may be improved by development of such a system. Potential applications include flight data recorders, structural integrity monitoring, pilot control advancement, and automated blade control.

A95-115TITLE:Numerically Efficient Rotorcraft Trim and Transient Response

CATEGORY: Exploratory Development

OBJECTIVE: Development of numerically efficient trim and transient response algorithms for comprehensive rotorcraft analyses.

DESCRIPTION: Increasingly sophisticated rotorcraft analyses often result in extremely long run times that are only partially offset by improved computer hardware. Runtimes must be reduced through more efficient computational algorithms. Two algorithm opportunities for substantially improving runtime are including aerodynamics in the Newton-Raphson Jacobian during time marching, and application of the identical-blade concept to computing periodic solutions. Currently, most comprehensive rotorcraft codes compute transient response using an implicit integration scheme; solving a set of nonlinear set of equations at each time step. The equations are usually solved using the Newton-Raphson method, which requires forming the Jacobian of those equations. But in many codes, only structural terms are used in forming the Jacobian, and aerodynamic terms are ignored. The number of Newton-Raphson iterations could be significantly reduced if a means were found to include the aerodynamic terms in the Jacobian, at least in an approximate fashion. Use of the identical blade concept in computing the periodic solution would improve runtime by reducing the number of degrees-of-freedom by a factor is often as large as the number of blades. This concept has been successfully used in conjunction with the harmonic balance algorithm to compute periodic solutions but it has had only. limited use for periodic solutions using the time marching algorithm. The algorithm has been successfully applied in

problems where the blades responses are entirely uncoupled, or coupled only through the aerodynamic wake. The algorithm has not yet been applied to models where rotor blades are coupled structurally through motion of the rotor hub, because the algorithm for doing this has not yet been fully developed or tested.

PHASE I: Develop an algorithm for including aerodynamic terms in the Newton-Raphson Jacobian of an implicit time integration scheme in a comprehensive rotorcraft code. Also, develop an algorithm for extending the identical blade concept to computing periodic solutions using time marching. Demonstrate these algorithms with test problems run on the comprehensive rotorcraft code.

PHASE II: Fully implement the algorithmic enhancements in a comprehensive rotorcraft code, and update the code's documentation to reflect the enhancements. Test the updated comprehensive code with a suite of test problems to demonstrate the runtime improvements to check the accuracy of the modified software, and to demonstrate the runtime improvements from the enhancements.

POTENTIAL COMMERCIAL MARKET: Validated comprehensive rotorcraft analysis capability is sorely needed in both military and commercial markets. This software provides finite element comprehensive analysis with improved, numerically efficient trim algorithms. This capability could be applied to all new commercial designs and product improvements reducing time and design and analysis cost.

A95-116TITLE:Improved Run Data Base for Comprehensive Rotorcraft Analysis Software

CATEGORY: Exploratory Development

OBJECTIVE: Development of an improved run data base for comprehensive rotorcraft analysis software

DESCRIPTION: Comprehensive rotorcraft analysis systems incorporate dynamic behavior from a variety of disciplines in one code, e.g. multi-body dynamics, structural dynamics, control dynamics, aerodynamics and fluid flow dynamics. Such programs tend to be long running, require and produce large amounts of data and are frequently run in stages. Thus, there is a requirement for data storage tailored to the needs of the code that retrieves and deposits data (input data, intermediate data structures, and output results) when it runs. The stored data remains resident on disk files when the code is not in use. Such data storage and the software that manipulates it is called a run data base (RDB). The data in the RDB must be transportable between machines of different architecture. It must not depend on licensed products since some comprehensive rotorcraft analysis software is freely distributed, and the recipients must not be required to acquire a license for the embedded RDB software. The software must be portable. The code must be written in a standards compliant way with a widely available efficient language (e.g., C++). It should be possible for user's to easily create, modify, and delete data structures in the RDB. Thus, a graphical user interface to the data structures which seems natural to the specialists in that discipline is required. The comprehensive code must be able to create, modify, and delete data structures in the RDB. Thus, a library of routines which can be called from comprehensive codes written in FORTRAN, C, and C++ must be produced. Since minimizing run time is of paramount importance for comprehensive programs, the code must be extremely efficient. Since data structures may be accessed within loops, it is important to minimize the time required for access. Furthermore, since many of the models in comprehensive analysis are constructed from sub-models, the RDB must support hierarchical data structures. Finally, the RDB must consist of a variety of data structures supporting the input, run time and output requirements for diverse disciplines.

PHASE I: Design the run data base and demonstrate its interface with a comprehensive rotorcraft analysis code. Produce design documentation.

PHASE II: Implement the run data base design with a comprehensive rotorcraft analysis code. Document the enhanced capabilities of the data base. Test the augmented comprehensive software and demonstrate the enhanced capability over the original code for a suite of test problems.

POTENTIAL COMMERCIAL MARKET: Validated comprehensive rotorcraft analysis capability is sorely needed in both military and commercial markets. This software provides finite element comprehensive analysis with an improved run data base. This capability could be applied to all new commercial designs and product improvements reducing time and design and analysis cost.

A95-117TITLE:Resolution of Induced and Profile Components of Aerodynamic Drag on Rotors in Hover and in Forward Flight

CATEGORY: Exploratory Development

OBJECTIVE: Establish and demonstrate new and innovative methods for efficient and accurate determination of aerodynamic drag forces acting on rotors in hover and in forward flight. The method developed must be capable of differentiating and individually quantifying the induced and the profile components of the drag force and must form a rational basis for drag reduction investigations.

DESCRIPTION: The problem of drag reduction is central to modern aerodynamic research and is of special importance to rotorcraft technology. A significant reduction in aerodynamic drag acting on rotors in hover and in forward flight can lead to substantial improvements in rotor performance, with corresponding benefits in rotorcraft payload and range capability. A qualitative understanding of various physical processes important to drag has been available for several decades. This understanding suggests that the drag force as well as the moment of the drag force acting on rotor blades can be significantly reduced through improved rotor designs. Unfortunately, this understanding is insufficient for quantifying the relative importance of the various features that are present in rotor flowfields. Experimental rotor aerodynamic data are at the present restricted mostly to total forces, component forces and surface pressures. On such a basis, it is difficult to differentiate the contributions of various flow mechanisms to drag. In particular, the resolution of the total drag into the profile drag and induced drag components is impracticable. The engineer interested in drag reduction must rely upon cut-and-try processes, which are often prohibitively costly and time- consuming, to arrive at desired design compromises. New and more efficient procedures for drag determination that can quantify individually the various contributors to aerodynamic drag on rotors are needed.

PHASE I: The vortical wake method for drag determination shall be established and calibrated for hovering rotors. The available vortical wake method is for steady flows in an inertia reference frame. The hovering rotor flowfield is steady only in a rotating reference frame. The effect of the reference-frame rotation on the wake integrals shall be determined and incorporated into the method. Computer programs shall be developed for the evaluation of the modified vortical wake integrals and of the associated induced and the profile drag components using experimental data for the vortical wake. Available AFDD aerodynamic force and wake data for the hovering rotor shall be utilized for the calibration of the modified method. Exploratory parametric studies shall be carried out to determine the effects of various geometric factors on the induced and the profile drag components.

PHASE II: The vortical wake method for drag determination shall be fully developed and calibrated for rotors in forward flight. The forward-flight rotor flowfield is intrinsically unsteady and the vortical wake integrals shall be derived for general unsteady flows. Computer programs shall be developed for the evaluation of the unsteady vortical wake integrals and of the associated unsteady induced and profile drag components. Forward-flight rotor experiments shall be planned and conducted to obtain vortical wake data as well as force balance data. These data shall be utilized in a thorough calibration of the method for rotors in forward flight. Parametric studies shall be carried out for both the hovering and the forward-flight rotors and design criteria for drag reduction shall be suggested.

POTENTIAL COMMERCIAL MARKET: This technology will have direct applications in the rotorcraft industry. In addition to rotors, the method as well as the data generated in this research are directly applicable to the design of both marine and aircraft propellers. The fully established technology, by creating a practical capability to quantify the induced and the profile drags individually, is expected to have a significant impact on future designs of fixed wing aircraft as well as ground and marine transport systems.

A95-118TITLE:Actuator/Sensor Arrays for Active Structural Control

CATEGORY: Engineering Development

OBJECTIVE: Design analyze and develop actuator/sensor arrays and associated control algorithms that provide active structural control for vibration suppression, shape control and/or damage detection/control

DESCRIPTION: Recent developments in miniature sensors and actuators and advances in high speed digital data transfer and computation lead to the possibility of real-time integration of structural dynamics with actuator/sensor arrays to achieve active structural control for improved efficiency. These actuators and sensors can be embedded in the material or attached to the surface. Examples of such devices include Micro-electricomechanical systems (MEMS), miniaturized standard instrumentation such as accelerometers, piezoelectric material embedded into composite material and used for both sensing and actuation, and optical fiber sensors. Individual actuators and sensors can be linked together with digital processing to form an actuator/sensor arrays. These arrays could provide spatial distribution of an active control system throughout the structure. Because the actuator/sensor array is spatially distributed, the structural surface deflections can be measured and controlled directly in real-time, with the sensor arrays providing the spatial information needed to define mode shapes and the actuator arrays providing specialized spatial integration of the structure. Enabling technologies include actuator/sensor selection and placement, control algorithms development, and distributed computing capabilities of the array.

PHASE I: Select a suitable problem to demonstrate structural control. Design methodology for increased structural efficiency through active control utilizing actuator/sensor arrays will be developed. Selection of actuator/sensor genre and design alternatives for the selected problem will be made. Control Algorithms will be developed and demonstrated in a laboratory experiment.

PHASE II: Optimize the actuator/sensor arrays for structural efficiency. Extended the laboratory experiment to a complex structure and account for nonlinearity and changes in the environment, allowing for reconfiguration of the arrays to accommodate the changing demands on the distributed computing capabilities of the arrays.

POTENTIAL COMMERCIAL MARKET: Active structural control for vibration suppression and damage detection/control on commercial aircraft using actuation/ sensor arrays has payoffs in reduced operational costs and ride comfort.

A95-119TITLE:Pressure-Based, Finite Volume, Unstructured, Solution-Adaptive Computational Fluid Dynamics (CFD) Code for Heat Transfer and Pollutant Dispersal

CATEGORY: Advanced Development

OBJECTIVE: Develop a pressure-based, finite volume, unstructed, solution- adaptive computational fluid dynamics (CFD) code for heat transfer and pollutant dispersal. Also, develop a thin wall porosity capability within the code. Efficiently implement on SMP architectures.

DESCRIPTION: The U.S. Army wishes to develop a CFD solver for simulating flow, heat transfer, and pollutant dispersal in and around mission critical electronics, porous battlefield hospital tents and combat vehicles. These computations will involve computing incompressible flow in complex geometrics and the tracking of unsteady pollutant fronts. The complexity of the geometrics involved makes unstructured grids and thin wall porosity necessary. Solution-adaptivity is desirable to resolve flow features of interest. Since the flows involved are incompressible, it is desirable that the solution algorithm be pressure-based. Mixed-mesh topologies are of interest to allow the greatest flexibility in mesh generation. Solution-adaptivity must include not only standard refinement and coarsening schemes involving conformal elements, but also adaption strategies involving hanging nodes for maximum flexibility. All aspects of the solver, including adaption, should be able to take advantage of parallel processing to accelerate the solution of these large unsteady problems. Because of adaption, methods which maintain balanced loads among all processor will be necessary. Efficient implementations on shared-memory symmetric multiprocessor (SMP) architectures are of particular interest. User-friendly pre-and post processing, including CAD geometry modeling tools and automatic mesh generation, are desirable.

PHASE I: Develop steady laminar/turbulent flow and heat transfer capability for hexahedral and tetrahedral meshes with solution-adaptivity using a pressure-based, finite volume, scheme with multispecies capability (pollutant dispersal).

PHASE II: Extend Phase I formulation to include unsteady flow, heat transfer and pollutant transport. Complete parallel processing for SGI Onyx platform and demonstrate code on unsteady, three-dimensional problems of interest to the Army. Train Army personnel in the use of the code.

POTENTIAL COMMERCIAL MARKET: This solver will find widespread use in commercial low-speed flow applications by greatly reducing the time for mesh generation, by optimally deploying mesh points through solution-adaption and by obtaining significant speed-up through parallel processing. The code will be used in the automotive, aerospace, chemical processing, electronics cooling, materials processing industries and in numerous other areas.

A95-120TITLE:Soldier Mobility Amplification

CATEGORY: Exploratory Development

OBJECTIVE: To develop and demonstrate products utilizing mature, as well as emerging, technologies that enhance the individual soldier capabilities in terrain traversal and/or load maneuvering by optimizing and amplifying human-generated energy.

DESCRIPTION: Increased mobility for the infantry soldier means running faster, marching longer, and climbing higher with the necessary stamina to complete the mission. The goal this effort is to provide system concepts to improve the mobility of the dismounted fighter, but without adding the weight and logistical requirements of an external power source. In other words, soldier-powered amplifiers for increased ground mobility. For example, devices that will enhance the soldier's performance through optimizing/directing energy exerted or by adding strength, agility, and/or speed utilizing energy storing material. Any product or device that enhances or amplifies the soldiers ability to traverse the battlefield without external power sources will be considered under this announcement. The realities of the military downsizing and increased mission responsibilities are proving detrimental to the dismounted fighter's ability to maneuver around the battlefield or conduct Operations Other Than War. Today's ground soldier is still carrying upwards of 100 lbs. into situations that may require traversing extreme or difficult terrain. And the

weights of these loads are increasing with more and more technology enhancements added to insure lethality, survivability and sustainability.

PHASE I: Identify and explore novel concepts that offer potential of enhancing the soldier's ground mobility performance without external power requirements or significant increases in overall weight and bulk. Submit proposals for technical feasibility and acceptance. Design and develop "breadboard" model(s) of chosen system(s) to prove functionality and bio-mechanical efficiencies.

PHASE II: Optimize the selected Phase I system(s) through refinement of design and/or material changes. Provide final technical report with full specification for optimized system(s).

POTENTIAL COMMERCIAL MARKET: This technology has many applications in industrial and construction areas.

A95-121TITLE:Stitchless Textile Fabrication System

CATEGORY: Advanced Development

OBJECTIVE: The objective of this proposal would be to develop a piece of equipment that allows textile materials to be slit, bounded and taped in a single passthrough operation.

DESCRIPTION: Separate commercial technology currently exists for ultrasonic slitting and heat seam taping. Combined, these technologies provide for stitchless hermetically sealed seaming technique for manufacture of textile based clothing, uniforms, tentage, parachutes and other end-item constructions. Advantages of these techniques include self-sealing capability (against all environments), good seam strength (stronger than 2 needle-felled sewn seam), good appearance, and ease of manufacturing; however, its disadvantage is that it requires a two-step operation (ultrasonic slitting followed by seam taping utilizing two separate machines).

PHASE I: Develop prototype equipment that allows for two synthetic based textile pattern pieces in a superimposed position to be either ultrasonic or laser cut or sliced through the pattern layers. Upon emerging either from the Ultrasonic Wheel or laser cutting beam the materials shall exhibit a smooth clean raw edge, that provides bonding strength enough for subsequent handling purposes. The raw edge, through some means of semi-automatic movement system, shall then be transported through a directed heat taping system operated either by hot air, ultrasonics or laser. Upon heating, the adhesive backed tape shall be pressurized sufficiently to allow the hot molten adhesive to penetrate the abutted materials of the pattern pieces. Upon cooling the adhesive cures and provides for a highly effective stitchless seam structure that inherently is self-sealing. The challenge is that the initial cutting conducted in an edge on edge position while the subsequent taping operation is conducted such that the tape (typically one-inch wide) straddles more or less 1/2 inch of each pattern piece while the pattern pieces maintain their adjoined bonded position. End results shall be a visible seam tape on one side of adjoined pattern pieces while just a thin adjoined line of smooth molten materials is visible on the opposite side of the pattern pieces with the line more or less located in the middle of the tape.

PHASE II: Wear test the Phase I equipment for a garment manufacturing evaluation.

- Recommend changes.
- Incorporate changes for finalized equipment manufacture and supply engineering drawings.
- Begin manufacture of equipment for government/commercial utilization.

POTENTIAL COMMERCIAL MARKET: End-item garments in the mens and women's dress, combat, utility and children's wear categories including home care (curtains, upholstery, etc.), automotive, outdoor tentage, awnings, backpacks, parachutes and virtually all currently sewn textile markets could potentially be constructed using such state-of-the-art equipment. All seams would be self-sealed, provide excellent seam strength, excellent appearance, and hasten end-item production, lower costs, provide better quality and open the path to a complete automation manufacturing system.

References:

1. Bi-monthly/final reports, Clemson University, Contract DAAK60-89-C-1070 "Development of Stitchless Chemical Protective Uniform". Video final report (VHS), Clemson University same contract. US Army Natick RD&E Center, various fabricated uniforms, samples, tape and fabric of same contract.

A95-122TITLE:Intelligent Sensor-Based Robotic Control System Technology

CATEGORY: Exploratory Development

OBJECTIVE: Develop a generic multi-adaptive robotic control module and development environment for mobile manipulator systems to be used in 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 80386-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 of mobility and base motion effects, flexible task level control, multi- sensor integration, multi-manipulator coordination associated with fusing ammunition in a moving resupply vehicle, and depalletizing and transferring ammunitions 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 for kinematically redundant robotic manipulators, voice natural language interface for control, multi-manipulator control strategies, world modeling design environment, real time control, 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 algorithm approaches to intelligent sensor based robotic control systems for applications in 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. Develop technology commercialization plan.

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 programs like the Future Armored Resupply Vehicle (FARV-A) and Advanced Field Artillery System (AFAS) to perform ammunition fusing, handling and loading during re-supply operations.

Cost Reduction: 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-palletizing and transferring of ammunition to and from re-supply vehicles.

A95-123TITLE:Non-Lethal Devices

CATEGORY: Exploratory Development

OBJECTIVE: To design, develop and demonstrate non-lethal devices capable of temporarily incapacitating / immobilizing personnel and materiel targets without lethality, serious injury, or excessive property destruction with dual-use application for law enforcement, or other direct technology transfer to private sector use.

DESCRIPTION: Rules of engagement necessarily restrict the use of deadly force in peacekeeping and humanitarian relief operations. There is a need to fill an intermediate force gap through the development of non-lethal devices / mechanisms that immobilize personnel and vehicles without inflicting casualties and while minimizing collateral damage. These devices are needed to provide non -lethal stand-off and force protection capabilities as well as tactical flexibility. In addition, these devices will simultaneously provide a dual-use, less than lethal capability for law

enforcement applications, or direct technology transferability to the commercial sector. Lethal vs. Non-lethal Effects: A critical area for the assessment of non-lethal devices is modeling and simulation based on actual, measurable parameters required to determine their effectiveness. This includes new test methods, bio-simulant effects, simulation models, battlefield effectiveness studies, and effects databases. Battlefield simulation modeling and verification test methods (e.g., against bio-simulant targets) are critical to evaluating the effectiveness and potential field utility of non-lethal devices before committing larger investments of resources.

PHASE I: Design, fabricate, test, and verify effectiveness of non- lethal devices with capability to temporarily incapacitate / immobilize personnel and vehicles. These devices will preferentially be versatile enough to deliver a range of effects from annoyance/discomfort up to lethality, or allow for near instantaneous switching / changeover from non-lethal to lethal from existing weapons platforms. Formulate and demonstrate concepts for specific devices including methodology and/or modeling of utility in peacekeeping and humanitarian assistance operational scenarios. If successful in phase I, there is a good potential for phase II. Initiate development of marketing plans for phase III efforts and identify user interest and potential for dual use applications. Desired Operational/Tactical Capabilities include: 1. Graded Response / Incremental Penalty: Provide a tunable level of incapacitation based on situation / task required. 2. Instantaneous Selection / Switching: Users require near instantaneous changeover from non-lethal to lethal "fire" from the same weapon / delivery platform. 3. Utilization of Existing Logistics Chain: Application to, or minor modification of, existing weapons systems are essential due to declining defense funds, and need to minimize basic load (weight). Highly applicable individual soldier platforms for non-lethal devices are hand-emplaced devices, handguns, batons, grenades (launched, hand-thrown), shotguns, M16 Rifle, machine guns, light mortars, or vehicle mounts.

PHASE II: Develop operable prototypes and conduct tests to evaluate performance against various bio-simulants or vehicle targets of interest. Evaluate reliability & effectiveness using war gaming models and simulated targets. Develop detailed plans for full integration into suitable weapon platforms / delivery vehicles (i.e. weaponization).

POTENTIAL COMMERCIAL MARKET: There is potential to use these devices for law enforcement applications, or for technologies required for successful operation to have direct commercial sector application. Potential for phase III is high. The military will use these items primarily, but not solely, for operations other than war where use of non-lethal force is appropriate to prevent and/or control escalation or to serve as force protection measures.

A95-124TITLE:Remote Fire Extinguishing System Technology

CATEGORY: Exploratory Development

OBJECTIVE: Develop a remote fire extinguishing system that will enable personnel to put out fires occurring at ammunition storage areas from safe distances and increase soldier survivability.

DESCRIPTION: The operating distances for existing fire extinguishing systems is within a very few feet of the fire, and is very dangerous for firefighting personnel who fight fires at ammunition storage areas. Many times a fire at an ammunition storage site is left to burn itself out resulting in the massive destruction of property, material, and at times the loss of lives. The accident that occurred at Camp Doha, Kuwait after Desert Storm is a good example. A fire resulted in the loss of millions of dollars worth of weapons and ammunition, and the loss of several lives during subsequent cleanup of scattered munitions. That damage could have been prevented if a fire extinguishing system had been available to fight the fire at a safe distance during its early stages. A remote system consisting of a launcher, propulsion device, and projectiles filled with fire extinguishing chemicals could be developed to solve this problem. The technical issues to be considered during the development of a Remote Fire Extinguishing System are: the launcher should be low cost, lightweight and able to withstand the pressures generated from a propulsion device. The propulsion device must be safe to use with the portable launcher and chemically filled projectile, and should launch the projectile at a 20 to 80 degree angle a distance 100 to 1500 feet. The projectiles should maintain their structural integrity during long term storage at the environments that the ammunition is likely to experience, (-60 to +165 degrees F) and should not release its fire extinguishing cargo until over the fire or at impact. The fire extinguishing chemicals must meet all

environmental requirements, and should be capable of extinguishing all types (wood, plastic, petroleum, propellant, etc.) of fire that could occur in an ammunition storage area.

PHASE I: Investigate new and innovative chemicals that can effectively extinguish fires that occur in ammunition storage areas. Design a projectile to allow for proper release of the fire extinguishing chemicals and withstand launch forces. Investigate the type of propulsion devices available that generate sufficient energy to launch the projectile safely. Develop a launcher that is low cost, lightweight, reusable, and is portable by one person. Develop a system design that integrates the launcher, propulsion device, and projectile as a Remote Fire Extinguishing System.

PHASE II: Develop test hardware and test plans for the Remote Fire Extinguishing System components (launcher, propulsion device, and projectile) and the total system. Fabricate prototype test hardware, conduct testing of the prototype, and provide a final report that includes component specifications, unit cost, and test results.

POTENTIAL COMMERCIAL MARKET: The technology developed under this program may be utilized in any commercial explosive, fuel, and other hazardous material storage areas. The system will enable personnel to put out fires from a safe distance and prevent the loss of lives and property.

Cost Reduction: A major fire in an ammunition storage area could mean the loss of lives, property, and supplies. The Army cannot afford to lose anything critical, especially during combat situations. This technology will provide safety to Army personnel, preventing the loss of lives, ammunition, supplies, weapons, and maybe even the battle.

A95-125TITLE:Advanced Nonlinear and Hybrid Systems Control Technology

CATEGORY: Exploratory Development

OBJECTIVE: Develop and demonstrate high-performance nonlinear, adaptive, and hybrid systems control technology for precision multi-target/ multi-platform 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 processing together with LQG/LTR and H-infinity design approaches. Further improvements in weapon accuracy and targeting performance are anticipated through the development of improved robust nonlinear and adaptive control laws, and hybrid control laws that account for both continuous as well as logical components of the system state vector. This project will address the broad spectrum of issues associated with the development of control law 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, nonlinear and hybrid system control laws for precision weapon stabilization, tracking and targeting. Formulate specific stabilization, tracking and targeting control laws/ decision strategies for multi-input, multi-output nonlinear plants, incorporating distributed smart sensor/actuators, along with friction, backlash, resonant modes, high impulse periodic disturbances, nonlinear compliance, sensor noise, and multi-target sensor input. Determine performance and robustness characteristics with respect to model errors associated with both continuous and logical components of the domain model. Provide analysis of hardware/software implementation requirements to achieve real time performance.

PHASE II: Develop a fully integrated design and prototyping environment for advanced nonlinear, adaptive and hybrid 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, design environment, and prototyping tools developed in this SBIR are applicable to manufacturing, machine tool, process control, and automation applications, including automobile and commercial aircraft manufacturing, robotics applications, precision instrumentation systems, flight controls etc. These applications are characterized by the presence of nonlinearities, parameter variations, backlash, friction and resonant modes, while large scale automation requires consideration of hybrid discrete event and continuous time system dynamics.

A95-126TITLE:6-DOF Isolation and Excitation Facility

CATEGORY: Advanced Development

OBJECTIVE: To develop a six degree-of-freedom (DOF) test and development facility that isolates and excites, in a precisely controlled manner, payloads and/or instruments whose mass may range from 1 kg up to 1000 kg.

DESCRIPTION: Tactical military hardware is typically tested and evaluated to ensure proper operation in their anticipated service environments. Precise excitation and measurements are vital in the test process. Presently, these tests and measurements are conducted with the use of electro-mechanical or electro-hydraulic actuators which inherently produce severe cross-coupling between axes. It is desired to develop a 6-DOF vibration excitation platform capable of precisely duplicating field level dynamics while minimizing the unwanted cross-coupling characteristic of classical mechanically-coupled test platforms. A need exists to develop and implement new innovative approaches to overcome present limitations. Payload and/or instrumentation masses may vary from 1 to 1000 kg, and their sizes may be up to 1 meter by 1 meter. The height is limited only by practical limitations (such as facility ceilings). The minimum stroke requirements are up to 25mm pk-pk (37.5 mm pk-pk desired). Acceleration levels are limited to sinusoidal levels of 5 G's pk and random levels of 5 G-rms. Random vibration shall be capable of producing 3-sigma peak acceleration levels.

PHASE I: Perform a comprehensive literature search and feasibility study of performing 6-DOF motion simulation via a magnetically levitated test platform. Generate detailed design of required test facility which will meet the stated test and evaluation criteria. A detailed report of the investigation shall be provided at the completion of the study. The final report shall contain a detailed outline of the research findings and a proposed solution and implementation plan. The proposal shall include both mechanical and control solution candidates.

PHASE II: Implement a functional prototype at the Dynamic Test Branch, Redstone Technical Test Center, Redstone Arsenal, AL. The prototype shall be a fully-functional 6-DOF test platform, including all related control hardware and software required to perform closed loop motion simulation.

POTENTIAL COMMERCIAL MARKET: Wide bandwidth 6-DOF excitation or motion simulation platforms have been a long-term goal of both the military and commercial shock and vibration communities. Current mechanically-coupled options have multiple limitations resulting primarily from mechanical cross-coupling effects. If 6-DOF excitation via a magnetically levitated test platform proves feasible, there will be a strong potential commercial market for such an alternative technology.